AET

MULTIFUNCTION MEASURING TRANSDUCER

Operation manual

47113964.2.023РЭ

Contents

⚠ WARNING! There is a safety symbol at the transducer warning you to use operation manual. It is essential in order to determine the nature of potential hazards and precautions. Do not proceed beyond a WARNING notice until the indicated conditions are fully understood and met.

This operation manual contains information for using the AET Multifunction Measuring Transducer (hereinafter designated "transducer") and information on packing, transportation and storage.

Read this manual before operating.

There are following abbreviations in this manual:

RMS – root-mean-square;
ROM – read-only memory
RTC – real-time clock

1 Description and Operation

1.1 General specification

Transducer is a device for measuring a.c. parameters of three-phase four-wire system and of three-phase three-wire system and converting it to output code by two RS-485 interfaces.

Transducer corresponds to specification ТУ 4221-013-47113964-2010.

Transducer is a hardware SSI product of the second order according to ГОСТ Р 52931-2008.

Power Supply: 220 V (+10%; –15%); 50Hz.

Transducer is a hardware product without galvanic link between input circuits and output circuits.

Transducer is mounted on the rails TH-35 IEC 60715-2003 or immediately on the panel.

Guard level IP20 (ГОСТ 14254-96, IEC 529-89).

Climatic category УХЛ3.1 (ГОСТ 15150-69).

Operating Environment: Group С4 (ГОСТ Р 52931-2008):

- Ambient Air Temperature .... - 40 to 55 °C;
- Relative Humidity at 35 °C .... up to 95 %;
- Atmospheric pressure .... 84-106 kPa (630-800 mm Hg).

Transducers are stable to the Vibration and concerned to N1 group according to ГОСТ Р 52931-2008.

Transducers are stable to the Atmospheric pressure and concerned to P1 group according to ГОСТ Р 52931-2008.

Reference conditions relative to each of the influence quantities are given in table 1.

Table 1 – Reference conditions of the influence quantities and tolerances or testing purposes

Influence quantity	Reference conditions (reference range)	Tolerances permitted for testing purposes applicable to a single reference value
Ambient Air Temperature	20 °C	± 5 °C
Relative Humidity	30 … 80 %	
Atmospheric pressure	84 … 106 kPa (630 … 800 m Hg)	
Location	Soever	
Magnetic field of external origin	Earth's magnetic field	
Supply Voltage	220 V	± 4.4 V
Waveform of the voltage supply	Sinusoidal	Distortion factor shall not exceed 5%
Frequency of the input signal	50 Hz	± 0.5 Hz
Waveform of the input signal	Sinusoidal	Distortion factor shall not exceed 5%
Input voltage	Nominal value	±2%
Input voltages unbalance factor	shall not exceed 2 %	

Example of the designation: Transducer AET 4 1 1 - 1 1 ТУ4221-013-47113964-2010

First four signs of product line designation* (**AET1**00, **AET2**00, **AET3**00, **AET4**00)	
Numerical code	Rated line-to-line voltage
1	100 V
2	380 V

Numerical code	Rated current, A
1	5.0
2	2.5
3	1.0
4	0.5

Numerical code	RTC option (timestamp setting)
1	yes
0	none

Numerical code	Communication support option (IEC 60870-5-101)
1	yes
0	none

* There are additional zeroes in the reference designation.

1.2 Technical characteristics

1.2.1 Transducer ensures the measuring of the a.c. parameters of three-phase four-wire system and three-phase three-wire system and converting measured data to output code by two RS-485 interfaces (see table 2 and table 3).

Communications protocol: MODBUS-RTU, MODBUS-ASCII IEC 60870-5-101 or «ExtDev» in accordance with 47113964.505100.054-01 90 03-1, 47113964.505100.054-01 90 03-2 and 47113964.505100.054-01 90 03-3.

Notes

1 Timestamp setting is enable, when the RTC option is imbedded only.

2 Selection of the measuring mode (between three-wire or four-wire system) is realized by user-configuration of transducer.

Table 2 – Parameters of three-wire system

Measurand	Designation	Output code value	Realization for product line				Comment
			AET100	AET200	AET300	AET400	
True RMS values of line-to-line voltage	U_{AB} U_{BC} U_{CA}	$k_1 \cdot U_{AB}/U_{L\text{-}L\ nom}$ $k_1 \cdot U_{BC}/U_{L\text{-}L\ nom}$ $k_1 \cdot U_{CA}/U_{L\text{-}L\ nom}$	+ + +	+ + +	+ + +	+ + +	
Average value of line-to-line voltage	U_{av}	$k_1 \cdot U_{av}/U_{nom}$	+	+	+	+	$U_{av} = \frac{1}{3}(U_{AB} + U_{BC} + U_{CA})$
True RMS values of phase current	I_A I_B I_C	$k_1 \cdot I_A/I_{nom}$ $k_1 \cdot I_B/I_{nom}$ $k_1 \cdot I_C/I_{nom}$	+ + +	+ + +	+ + +	+ + +	
Average value of line-to-neutral voltage	I_{av}	$k_1 \cdot I_{av}/I_{nom}$	+	+	+	+	$I_{av} = \frac{1}{3}(I_A + I_B + I_C)$
Active power of three-phase system	P	$k_2 \cdot P/P_{nom}$	–	+	+	+	$P = P_{AB} + P_{CB}$, where $P_{AB} = U_{AB} I_A \cos\varphi_{UAB,IA}$; $P_{CB} = U_{CB} I_C \cos\varphi_{UCB,IC}$
Reactive power of three-phase system	Q	$k_2 \cdot Q/Q_{nom}$	–	–	+	+	$Q = Q_{AB} + Q_{CB}$, where $Q_{AB} = U_{AB} I_A \sin\varphi_{UAB,IA}$; $Q_{CB} = U_{CB} I_C \sin\varphi_{UCB,IC}$
Apparent power	S	$k_2 \cdot S/S_{nom}$	–	–	+	+	$S = \sqrt{(P^2 + Q^2)}$
Frequency	f	$k_3 \cdot f/f_{nom}$	–	–	–	+	

Notes

1 The sign «+» identifies when the function is realized. The sign «–» identifies when the function is not realized.

2 k_1, k_2, k_3 - resolution factors.

When configuring the transducer:

- k_1 can be established from 2500 to 5000;
- k_2 can be established from 1000 to 5000;
- k_3 can be established from 20000 to 50000.

3 The index «nom» denotes nominal value

Table 3 – Parameters of four-wire system

Measurand	Designation	Output code value	Realization for product line				Comment
			AET100	AET200	AET300	AET400	
True RMS values of line-to-line voltage	U_{AB} U_{BC} U_{CA}	$k_1 \cdot U_{AB}/U_{L\text{-}L\ nom}$ $k_1 \cdot U_{BC}/U_{L\text{-}L\ nom}$ $k_1 \cdot U_{CA}/U_{L\text{-}L\ nom}$	+ + +	+ + +	+ + +	+ + +	
Average value of line-to-line voltage	U_{av}	$k_1 \cdot U_{av}/U_{nom}$	+	+	+	+	$U_{av} = \frac{1}{3}(U_{AB} + U_{BC} + U_{CA})$
True RMS values of line-to-neutral voltage	U_A U_B U_C	$k_1 \cdot U_A/U_{L\text{-}N\ nom}$ $k_1 \cdot U_B/U_{L\text{-}N\ nom}$ $k_1 \cdot U_C/U_{L\text{-}N\ nom}$	+ + +	+ + +	+ + +	+ + +	
Average value of line-to-neutral voltage	$U_{L\text{-}Nav}$	$k_1 \cdot U_{L\text{-}Nav}/U_{nom}$	+	+	+	+	$U_{L-Nav} = \frac{1}{3}(U_A + U_B + U_C)$
True RMS value of zero-sequence voltage	U_0	$k_1 \cdot U_0/U_{L\text{-}N\ nom}$	+	+	+	+	
True RMS values of phase current	I_A I_B I_C	$k_1 \cdot I_A/I_{nom}$ $k_1 \cdot I_B/I_{nom}$ $k_1 \cdot I_C/I_{nom}$	+ + +	+ + +	+ + +	+ + +	
Average values of phase current	I_{av}	$k_1 \cdot I_{av}/I_{nom}$	+	+	+	+	$I_{av} = \frac{1}{3}(I_A + I_B + I_C)$
True RMS value of zero-sequence current	I_0	$k_1 \cdot I_0/I_{nom}$	+	+	+	+	
Active power, per phase	P_A P_B P_C	$k_2 \cdot P_A/P_{ph\ nom}$ $k_2 \cdot P_B/P_{ph\ nom}$ $k_2 \cdot P_C/P_{ph\ nom}$	– – –	+ + +	+ + +	+ + +	$P_A = U_A I_A \cos\varphi_A$ $P_B = U_B I_B \cos\varphi_B$ $P_C = U_C I_C \cos\varphi_C$
Active power of three-phase system	P	$k_2 \cdot P/P_{nom}$	–	+	+	+	$P = P_A + P_B + P_C$
Apparent power, per phase	S_A S_B S_C	$k_2 \cdot S_A/S_{ph\ nom}$ $k_2 \cdot S_B/S_{ph\ nom}$ $k_2 \cdot S_C/S_{ph\ nom}$	– – –	– – –	+ + +	+ + +	$S_A = U_A I_A$ $S_B = U_B I_B$ $S_C = U_C I_C$
Apparent power of three-phase system	S	$k_2 \cdot S/S_{nom}$	–	–	+	+	$S = \sqrt{(U_A^2 + U_B^2 + U_C^2)} \cdot$ $\cdot \sqrt{(I_A^2 + I_B^2 + I_C^2)}$
Reactive power, per phase	Q_A Q_B Q_C	$k_2 \cdot Q_A/Q_{ph\ nom}$ $k_2 \cdot Q_B/Q_{ph\ nom}$ $k_2 \cdot Q_C/Q_{ph\ nom}$	– – –	– – –	+ + +	+ + +	$Q_A = U_A I_A \cdot \sin\varphi_A$ $Q_B = U_B I_B \sin\varphi_B$ $Q_C = U_C I_C \sin\varphi_C$
Reactive power of three-phase system	Q	$k_2 \cdot Q/Q_{nom}$	–	–	+	+	$Q = Q_A + Q_B + Q_C$

Continuation of the Table 3

Reactive power, per phase (absolute value)	Q_{FA} Q_{FB} Q_{FC}	$k_2 \cdot Q_{FA}/Q_{phnom}$ $k_2 \cdot Q_{FB}/Q_{ph\ nom}$ $k_2 \cdot Q_{FC}/Q_{ph\ nom}$	– – –	– – –	+ + +	+ + +	$Q_{FA} = \sqrt{(S_A^2 - P_A^2)}$ $Q_{FB} = \sqrt{(S_B^2 - P_B^2)}$ $Q_{FC} = \sqrt{(S_C^2 - P_C^2)}$
Frequency	f	$k_3 \cdot f/f_{ном}$	–	–	–	+	

Notes

1 The sign «+» identifies when the function is realized. The sign «–» identifies when the function is not realized.

2 k_1, k_2, k_3 - resolution factors.

When configuring the transducer:

- k_1 can be established from 2500 to 5000;
- k_2 can be established from 1000 to 5000;
- k_3 can be established from 20000 to 50000.

3 The index «nom» denotes nominal value

1.2.2 Nominal quantities (voltage, current and power) are given in table 4.

Nominal frequency f_{nom} ………………… 50 Hz

Nominal power factor:

active ……………………………………….. cos φ =1

reactive …………………………………….. sin φ = 1

1.2.3 Operation ranges of input signals are given in table 5.

1.2.4 Limits of intrinsic error **γ** and quantum values are given in table 6.

1.2.5 Variations from influencing magnitudes correspond to table 7.

1.2.6 Error due to distortion of the input signal

When distortion factor vary from 5 up to 30 % for voltage and from 5 up to 50 % for current (for harmonics to 13th), limits of error are:

± 0.4 % of the fiducial value for measured phase current, line-to-line voltage and line-to-neutral voltage;

± 0.5 % of the fiducial value for measured zero-sequence voltage and zero-sequence current;

± 0.6 % of the fiducial value for measured power.

Note – Input amplitudes shall not exceed $1.2U_{nom} \cdot \sqrt{2}$ and $1.2I_{nom} \cdot \sqrt{2}$.

1.2.7 Error of the inbuilt RTC lies within ± 2.6 second per day. Error of the timestamp setting doesn't exceed 10 ms providing that synchronization is operated.

1.2.8 Refresh rate of the data register is 6 Hz.

1.2.9 Time between reception of the request and the beginning information output is no more than 15 ms.

Table 4

Product line	Designation	Nominal value				
		Voltage line-to-line $U_{L\text{-}L\ nom}$, V	Voltage line-to-neutral $U_{L\text{-}N\ nom}$,V	Current, per phase I_{nom}, A	Power, per phase $P_{ph\ nom}$, W $Q_{ph\ nom}$, var $S_{ph\ nom}$, V·A	Power of the sistem P_{nom}, W Q_{nom}, var S_{nom}, V·A
AET100	AET111	100	100/√3	5.0	500 / √3	500 ·√3
	AET112			2.5	250 / √3	250 ·√3
	AET113			1.0	100 / √3	100 ·√3
	AET114			0.5	50 / √3	50 ·√3
	AET121	380	380/√3	5.0	1900 / √3	1900 ·√3
	AET122			2.5	950 / √3	950 ·√3
	AET123			1.0	380 / √3	380 √3
	AET124			0.5	190 / √3	190 ·√3
AET200	AET211	100	100/√3	5.0	500 / √3	500 ·√3
	AET212			2.5	250 / √3	250 ·√3
	AET213			1.0	100 / √3	100 ·√3
	AET214			0.5	50 / √3	50 ·√3
	AET221	380	380/√3	5.0	1900 / √3	1900 ·√3
	AET222			2.5	950 / √3	950 ·√3
	AET223			1.0	380 / √3	380 ·√3
	AET224			0.5	190 / √3	190 ·√3
AET300	AET311	100	100/√3	5.0	500 / √3	500 ·√3
	AET312			2.5	250 / √3	250 ·√3
	AET313			1.0	100 / √3	100 ·√3
	AET314			0.5	50 / √3	50 ·√3
	AET321	380	380/√3	5.0	1900 / √3	1900 ·√3
	AET322			2.5	950 / √3	950 ·√3
	AET323			1.0	380 / √3	380 ·√3
	AET324			0.5	190 / √3	190 ·√3
AET400	AET411	100	100/√3	5.0	500 / √3	500 ·√3
	AET412			2.5	250 / √3	250 ·√3
	AET413			1.0	100 / √3	100 ·√3
	AET414			0.5	50 / √3	50 ·√3
	AET421	380	380/√3	5.0	1900 / √3	1900 √3
	AET422			2.5	950 / √3	950 ·√3
	AET423			1.0	380 / √3	380 ·√3
	AET424			0.5	190 / √3	190 ·√3

Table 5

Name of parameter	Operation range
Current	0 … 120 % of the nominal current
Voltage when voltage and power are measured when frequency is measured	 0 … 120 % of the nominal voltage 10 … 120 % of the nominal voltage
Power factor active *cos φ* reactive *sin φ* (when Q_A, Q_B, Q_C, Q) reactive *sin φ* (when Q_{FA}, Q_{FB}, Q_{FC})	 ±(0….1…0) ±(0….1…0) ±(0.5….1…0.5)
Frequency	45 … 65 Hz

Table 6

Measurand	γ, %	Fiducial value	Quantum value
True RMS values of line-to-line voltage	±0.2	$U_{L\text{-}L\ nom}$	$U_{L\text{-}L\ nom}/k_1$
Average value of line-to-line voltage	±0.2	$U_{L\text{-}L\ nom}$	$U_{L\text{-}L\ nom}/k_1$
True RMS values of line-to-neutral voltage	±0.2	$U_{L\text{-}N\ nom}$	$U_{L\text{-}N\ nom}/k_1$
Average value of line-to-neutral voltage	±0.2	$U_{L\text{-}N\ nom}$	$U_{L\text{-}N\ nom}/k_1$
True RMS value of zero-sequence voltage	±0.2	$U_{L\text{-}N\ nom}$	$U_{L\text{-}N\ nom}/k_1$
True RMS values of phase current	±0.2	I_{nom}	I_{nom}/k_1
Average values of phase current	±0.2	I_{nom}	I_{nom}/k_1
True RMS value of zero-sequence current	±0.2	I_{nom}	I_{nom}/k_1
Active power, per phase	±0.5	$P_{ph\ nom}$	$P_{ph\ nom}/k_2$
Active power of three-phase system	±0.5	P_{nom}	P_{nom}/k_2
Reactive power, per phase	±0.5	$Q_{ph\ nom}$	$Q_{ph\ nom}/k_2$
Reactive power of three-phase system	±0.5	Q_{nom}	Q_{nom}/k_2
Apparent power, per phase	±0.5	$S_{ph\ nom}$	$S_{ph\ nom}/k_2$
Apparent power of three-phase system	±0.5	S_{nom}	S_{nom}/k_2
Frequency	±0.02	f_{nom}	f_{nom}/k_3

Note

When configuring the transducer:

- k_1 can be established from 2500 to 5000;
- k_2 can be established from 1000 to 5000;
- k_3 can be established from 20000 to 50000.

Table 7

Name of influencing magnitude	Value of influencing magnitude	Variation, % of the fiducial value
Ambient Air Temperature for measurable current and voltage for measurable power for measurable frequency	- 40 to 55 °C	 ± 0.1 on 10 °C of temperature variation ± 0.2 on 10 °C of temperature variation ± 0.02 on 10 °C of temperature variation
Relative Humidity for measurable current and voltage for measurable power for measurable frequency	to 95% at 25 °C	 ± 0.2 ± 0.5 ± 0.02
External magnetic field of frequency 45 … 65 Hz by strength for measurable current and voltage for measurable power for measurable frequency	to 400 A/m	 ± 0.2 ± 0.5 ± 0.04

1.2.10 Rate of exchange (from 1200 to 76800 bps).

1.2.11 Intrinsic error corresponds to 1.2.4:

– on the expiry of a setup time;

– when auxiliary supply voltage fluctuating from 187 up to 242 V; auxiliary supply frequency fluctuating from 48 up to 52 Hz;

– under effecting sine-wave vibrations in a frequency band from 10 up to 55 Hz with displacement amplitude 0,15 mm.

1.2.12 Transducer withstands following overloads by input signals:

- for voltage inputs: the twofold nominal value applied for 2 h;
- for current inputs:
  - the sevenfold nominal value applied for 15 s and repeated two times at 60 s interval;
  - the tenfold nominal value applied for 5 s and repeated two times at 10 s interval;
  - the twentyfold nominal value applied for 1 s and repeated 5 times at 300 s interval.

1.2.13 Transducers are satisfied to the electromagnetic compatibility requirements for grade «A» equipment according with ГОСТ Р 51522.

1.2.14 Isolation of electric circuits concerning the case and amongst current circuits, voltage circuits, supply withstands a testing voltage of practically sine-wave shape by frequency (50 ± 2) Hz during 1 min:

- 2.5 kV RMS – in standard conditions;
- 1.5 kV RMS – to 95% R.H. at 35°C.

1.2.15 Isolation between independent circuits RS-485(1) and RS-485(2) is tested by approximate sine-wave shape (50 ± 2) Hz voltage during 1 min:

- 0.5 kV RMS – in standard conditions;
- 0.3 kV RMS – to 95% R.H. at 35°C.

1.2.16 Electrical insulation resistance of circuits pointed in 1.2.14 and 1.2.15 is not less:

- 40 MΩ - in standard conditions;
- 10 MΩ - to 80% R.H. at 55°C;
- 2 MΩ - to 95% R.H. at 35°C.

1.2.17 Power supply consumption ………………… 2.8 V·A;
Input power consumption:
- current circuit ……………………………… 0.2 V·A;
- voltage circuit (U nom = 100 V) …........ 0.2 V·A;
- voltage circuit (U nom = 380 V) …..….. 0.6 V·A;

1.2.18 Overall dimension ….. 120x80x120 mm.
1.2.19 Weight ………………. 0.85 kg.

1.3 Construction

1.3.1 General Form of the transducer is presented in Annex A.
1.3.2 Transducer has the following parts:

- Interface board;
- Meter board;
- Case;
- Cover.

Interface board and Meter board are produced of fiber-glass plastic with surface-mount technology.
Case and Cover are produced of plastic material.
Interface board and Meter board connect through leading-in sockets.
Supply transformer and three measuring transformers are on the meter board. Inside a case the meter board is arrested by guide ridge.
The contacts established on a cover ensure strengthening of the interface board.
The cover is mounted to a case through four screws, which can be sealed up.
The connection on the RS-485 service interface is made through a special hole in a cover. The hole is closed by a protective patch.
The latch ensures mounting the transducer to the rail or panel depending on variant of installation.

1.4 Functional description

1.4.1 The transducer is a device with digital processing of a signal.
The transducer consists of following reference nodes:
– Metering Circuit;
– Interface;
– Power source.
1.4.2 Metering Circuit consists of three identical measuring lines.
Each measuring line contains a voltage channel and current channel.
Each channel consists of input stage, low-pass filter (LPF), analog-to-digital converter (ADC) and computational part.
When reactive power is measured, a Hilbert transformer is used in the computational part of the voltage channel.
Voltage cascades are the scaling amplifiers and have immediate galvanic communication with input voltage circuits. Current cascades are carried out with the compensation circuits on measuring transformers and ensure a galvanic isolation of the measuring current circuits.
The input cascades convert input signals of voltage and current into the proportional output voltage that is transmitted to inputs of six-channel ADC.
ADC functions the discrete sampling and converting of the input signal into a 16-bit binary code. Sampling frequency is 3125 Hz.
Calculation of parameters which the transducer output delivers is realized by microcontroller.
1.4.3 Basic formulas are presented in tables 8, 9.

Table 8 Formulas for the calculation of parameters of three-phase four-wire system

Name of parameter	Designation	Formula
True RMS value of line-to-line voltage	U_{AB} U_{BC} U_{CA}	$U_{AB}=\sqrt{\frac{1}{N}\sum_{i=0}^{N-1}(u_{Ai}-u_{Bi})^2}$, $U_{BC}=\sqrt{\frac{1}{N}\sum_{i=0}^{N-1}(u_{Bi}-u_{Ci})^2}$, $U_{CA}=\sqrt{\frac{1}{N}\sum_{i=0}^{N-1}(u_{Ci}-u_{Ai})^2}$
Average value of line-to-line voltage	U_{AV}	$U_{AV}=\frac{1}{3}(U_{AB}+U_{BC}+U_{CA})$
True RMS value of line-to-neutral voltage	U_A U_B U_C	$U_{PH}=\sqrt{\frac{1}{N}\sum_{i=0}^{N-1}u_{PHi}^2}$
Average value of line-to-neutral voltage	U_{AVph}	$U_{AVph}=\frac{1}{3}(U_A+U_B+U_C)$
True RMS value of zero-sequence voltage	U_0	$U_0=\frac{1}{3}\sqrt{\frac{1}{N}\sum_{i=0}^{N-1}(u_{Ai}+u_{Bi}+u_{Ci})^2}$
True RMS values of phase current	I_A I_B I_C	$I_{PH}=\sqrt{\frac{1}{N}\sum_{i=0}^{N-1}i_{PHi}^2}$
Average values of phase current	I_{AV}	$I_{AV}=\frac{1}{3}(I_A+I_B+I_C)$
True RMS value of zero-sequence current	I_0	$I_0=\frac{1}{3}\sqrt{\frac{1}{N}\sum_{i=0}^{N-1}(i_{Ai}+i_{Bi}+i_{Ci})^2}$
Active power, per phase	P_A P_B P_C	$P_{PH}=\frac{1}{N}\sum_{i=0}^{N-1}u_{PHi}\cdot i_{PHi}$
Active power of three-phase system	P	$P=P_A+P_B+P_C$
Apparent power, per phase	S_A S_B S_C	$S_{PH}=U_{PH}\cdot I_{PH}$
Apparent power of three-phase system	S	$S=\sqrt{U_A^2+U_B^2+U_C^2}\cdot\sqrt{I_A^2+I_B^2+I_C^2}$
Reactive power, per phase	Q_A Q_B Q_C	$Q_{PH}=\frac{1}{N}\sum_{i=0}^{N-1}u_{\perp PHi}\cdot i_{PHi}$
Reactive power of three-phase system	Q	$Q=Q_A+Q_B+Q_C$
Reactive power, per phase (modulus)	Q_{FA} Q_{FB} Q_{FC}	$Q_{FPH}=\left\|\sqrt{S_{PH}^2-P_{PH}^2}\right\|$

Notes

1 There are following designations:

u_{Ai}, u_{Bi}, u_{Ci} - samples of instantaneous line-to-neutral voltages;

i_{Ai}, i_{Bi}, i_{Ci} - samples of instantaneous phase currents;

u_{PHi}, i_{PHi} - samples of instantaneous line-to-neutral voltages U_A, U_B, U_C and respective samples of instantaneous phase currents I_A, I_B, I_C;

$u_{\perp PHi}$ - samples of instantaneous line-to-neutral voltages subjected to Hilbert transformer;

N – quantity of samples per ≈ 0.1638 s time interval

2 The generalizing designation «PH» is applied for the phase indexes $_{A,B,C}$ for the calculation of phase parameter

Table 9 Formulas for the calculation of parameters of three-phase three-wire system

Name of parameter	Designation	Formula
True RMS value of line-to-line voltage	U_{AB} U_{BC} U_{CA}	$U_{AB} = \sqrt{\frac{1}{N}\sum_{i=0}^{N-1}(u_{Ai}-u_{Bi})^2}$, $U_{BC} = \sqrt{\frac{1}{N}\sum_{i=0}^{N-1}(u_{Bi}-u_{Ci})^2}$, $U_{CA} = \sqrt{\frac{1}{N}\sum_{i=0}^{N-1}(u_{Ci}-u_{Ai})^2}$
Average value of line-to-line voltage	U_{AV}	$U_{AV} = \frac{1}{3}(U_{AB}+U_{BC}+U_{CA})$
True RMS values of phase current	I_A I_B I_C	$I_A = \sqrt{\frac{1}{N}\sum_{i=0}^{N-1} i_{Ai}^2}$; $I_B = \sqrt{\frac{1}{N}\sum_{i=0}^{N-1} i_{Bi}^2}$; $I_C = \sqrt{\frac{1}{N}\sum_{i=0}^{N-1} i_{Ci}^2}$
Average values of phase current	I_{AV}	$I_{AV} = \frac{1}{3}(I_A+I_B+I_C)$
Active power of three-phase system	P	$P = \frac{1}{N}\sum_{i=0}^{N-1}[(u_{Ai}-u_{Bi})\cdot i_{Ai} + (u_{Ci}-u_{Bi})\cdot i_{Ci}]$
Reactive power of three-phase system	Q	$Q = \frac{1}{N}\sum_{i=0}^{N-1}[(u_{\perp Ai}-u_{\perp Bi})\cdot i_{Ai} + (u_{\perp Ci}-u_{\perp Bi})\cdot i_{Ci}]$
Apparent power of three-phase system	S	$S = \left\|\sqrt{P^2+Q^2}\right\|$

Note

The following designations employed:

u_{Ai}, u_{Bi}, u_{Ci} - samples of instantaneous voltages;

i_{Ai}, i_{Bi}, i_{Ci} - samples of instantaneous phase currents;

$u_{\perp Ai}$, $u_{\perp Bi}$, $u_{\perp Ci}$ - samples of instantaneous voltages subjected to Hilbert transformer;

N – quantity of samples per ≈ 0.1638 s time interval

1.4.4 Frequency measurement

The input signal of measured frequency (Ubc) arrives at an analog comparator input of a microcontroller. The frequency measurement is based on measuring of a fundamental frequency period. For this purpose, time clocks of the microcontroller are used. These are clocked from the internal source 16 MHz. The measured period value arrives at the digital filter which reduces noise content. The digital filter output value is used for the dividing of a constant stored in a microcontroller's ROM. The dividing result is a frequency output code.

1.4.5 The interface is implemented on the microcontroller and used to transducer data read transaction from the upper level controller. The address space configuration and calculator settings are stored in it.

The interface has two galvanic isolated outputs RS-485 by MODBUS-RTU, MODBUS-ASCII, IEC 60870-5-101 or «ExtDev» .

To make a user-configuration of the transducer, user can apply the program
«SetComplex 3.1 (EN)». (See the Annex B).

To configure the transducer and to confirm real values of the metrological characteristic, the user can apply the «SetComplex 3.1 (EN)» и «ComplexMet 3 EN». (See the Annex B, C).

1.4.6 Power source consists of the supply transformer, rectifier units and integrated linear voltage regulators.

1.5 Marking and sealing

1.5.1 The following information is marked on a cover of the transducer:

- The name and type designation;
- Manufacturer's mark;
- The nominal values of voltage and frequency of the supply;
- The nominal values and unit symbols of input signals;
- The value of maximum main power;
- Frequency range of the input signal
- The category of measurements;
- Designation of numbers and purposes of terminals;
- The sign ⚠ ;
- The sign «3~»;
- Serial number and two last digits of Issue Year.
- Inscription «Made in Russia»
- The sign of conformity (granting the registered declaration conformity).

1.5.2 Sealing of the transducer is yielded with a bitumen mastic №1 (according to ГОСТ 18680-73) applies on one cover screw out of four.

1.6 Packing

1.6.1 Transducers are delivered in distribution packaging.

1.6.2 The packing note is enclosed in the transport container.

1.6.3 The transducer is packaged into individual packing.

The passport and CD with software are inserted inside of the individual packing.

2 Intended Use

2.1 Operational constraints

2.1.1 Do not operate the transducer in the presence of explosion-hazard and hostile environment.
2.1.2 The transducer must not be effected by direct heat up to temperature more 50°C.
2.1.3 The transducer should be placed on the premises without sharp temperature fluctuation and far off of the sources of strong electromagnetic field.

2.2 Preparation for use

2.2.1 Check integrity of packing after deriving the transducer. Unpack it. Take out the transducer, make external examination, and be convinced of absence of visual mechanical failures. Check completeness of delivering according to table 10.

Table 10

Name and nomenclature	Designation	Quantity
Transducer		1
AET Multifunction measuring transducer. Passport	47113964.2.023ПС	1
AET Multifunction measuring transducer. Operation manual	47113964.2.023РЭ	1*
Individual package		1
Latch		1**
Connector 15EDGK-3,81-04P		1
Protective sticker		5
CD with software		1
* Set in the CD ** Set on the case		

2.2.2 Check the correspondence of information on a transducer cover to required parameters.

2.3 Use

2.3.1 All operations on mounting and maintenance should be making in order of operating rules on provision of safe service.
2.3.2 Make arranging a place of mounting of the transducer on plant according to an Annex D

⚠ ATTENTION! BUILDING WIRING WORK SHOULD INCLUDE THE AUTOMATIC DISCONNECTION SUPPLY DEVICE OR CLOSELY SET SWITCHING-OFF DEVICE FOR MANUAL SHUTTING DOWN OF THE TRANSDUCER.

APPLYING OF THE 1 Amp ELECTRIC FUSE IN THE EXTERNAL CIRCUIT IS RECOMMENDED.

2.3.3 The transducer must be configured according with table 11.

Table 11

Name and nomenclature	Value and meaning
Password for configuration	12345
Data exchange parameters by RS-485(1) and RS-485(2): - baud rate, bps - stop bit quantity - parity - device code - communication protocol - memory cell size (byte)	 9600 2 NO 1 MODBUS ASCII 2
Measurement mode (3 or 4-wire system)	4-wire system
Measurement parameters Registers address Register size, byte Resolution factor for every measurand k_1 k_2 k_3 group ID	 In according with 47113964.505100-01 90 03-1 2 5000 5000 50000 1

2.3.4 Before the mounting of the transducer at the object it is necessary to set requiring configuration by «SetComplex 3.1 (EN)».

A computer for this purpose has to meet following minimum system requirements:

- Windows 9x/NT/XP/Vista/7;
- Pentium 100 Processor or higher;
- 32 MB RAM;
- SVGA video adapter;
- USB interface ;
- CD-ROM.

Before the connection of the transducer unstick the protection sticker from the cover. .

To be configuration is authorized apply only valid password. The default password of the transducer is «12345»

«SetComplex 3.1 (EN)» description is presented in the Annex B.

If it isn't assumed to use the interface RS-485(2) after configuration, the protective patch should be placed on the transducer front panel.

2.3.5 The transducer enables to transfer the measurement data to the external indication device (supplied on separate request).

- AED is the seven-segment display indication device. It indicates three selected parameters and set points (30 devices into one transducer maximum).
- AEGD is the indication device performed on the graphic display. It indicates three snapshots with eight selected parameters alternately.

The external indication device image the data by way of four-digit decimal number which corresponded to measurand expressed in measurement unit. The transformer ratio of the external current and voltage transformers is taken into account. The updating rate of data is 3 Hz.

Transferring of the measurement data to the external indication device is carried out by the RS-485(2) interface with applying of the «ExtDev» communication protocol.

2.3.6 Installation of the transducer

2.3.6.1 Mounting the transducer ***on the rail***:

- place a latch according to figure D.1 to link the protuberances of the case to edge of the rail;
- push the case to fix.

The mounting of the transducer on the rail is supposed at mount the rail on a horizontal or vertical plane.

The distortion of the rail at the vertical plane towards the horizontal position should not be more than 15°.

2.3.6.2 Mounting of the transducer ***on the panel***:

- fix a latch on the panel by two screws according to figure D.2;
- pull the latch over the transducer by special construction hollow on the case.

Use two 4 mm diameter screws to fasten a latch on the panel. Screws shouldn't overhang beyond the bound of the mounting area. Mounting the transducer on a latch is necessary to provide not less than 15 mm space for initial fixing of the transducer.

2.3.7 Fix exterior conductive wires on terminals according to the diagram of transducer connections which is located in the Annex E.

A transducer connection by RS-485 interface should be executed with shielded twisted pair in accordance to Figure E.7.

The wire section should be not less 0.2 mm^2.

The wave resistance of the wire should be 120 Ω

2.3.8 Verify the correspondence of the signal source output parameters to requiring data-in of the transducer. Verify quality of wiring.

2.3.9 Turn on supply voltage 220 V and input signals on the transducer.

2.4 Operation in extreme conditions

2.4.1 Turn out the transducer immediately in case of originating an emergency condition of operation.

⚠ Apply the automatic disconnection supply device or closely set switching-off device for manual shutting down of the transducer.

3 Verification procedure

The present section regulates methods and means of verification of the transducer.
The interval between verifications should be 7 years.

3.1 Verification Operations and Test Equipment

3.1.1 The table 12 contains executable operations and Verification test Equipment.
3.1.2 In case of discrepancy to the list of test equipment, the applied model should satisfy to the requirements.
3.1.3 Verification Test Equipment should be operable and certified.
3.1.4 When negative results are obtained, the verification should be stopped.

3.2 Safety requirements

3.2.1 To avoid the electric shock, the safety measures described at the Test Equipment manual should be strictly observed.
3.2.2 Verification Test Equipment should be safely grounded if it's specified.

3.3 Verification condition and preparation for it

3.3.1 Standard conditions during verification correspond to table 1.
3.3.2 The transducer must be standing in normal climatic requirements at least 2 hours before the verification.
3.3.3 The means of verification are prepared according to the requirements of their operation documentation.

Table 12

Name of procedure	Item number of a procedure	Verification Test Equipment Specifications
External examination	3.4.1	–
Insulation resistance test	3.4.2	Megohmmeter **М4101/3** ТУ 25-04.2130-78 Range of measured resistances from 0 to 100 MΩ Measuring voltage 500 V
Intrinsic error test	3.4.3.6 3.4.3.7 3.4.3.8	Multifunction calibrator **«Ресурс-К2»(Resurs-K2)** ТУ 422953-005-53718944-00 Nominal value of line-to-neutral voltage 220 V; 57.7 V; accuracy 0.05% Nominal value of phase current 5 A; 1A; accuracy 0.05% Frequency range 45-65 Hz; accuracy 0.005 Hz Phase angle from minus 180° to 180°; accuracy ±0.03° Active, reactive, apparent power values with accuracy 0.1% Frequency counter 53131A Internal time base stability $\pm 5 \cdot 10^{-6}$ Computer: Windows 9x/NT/XP/Vista/7 Processor Pentium 100 MHz or higher 32 MB RAM SVGA video adapter RS-232 (COM2), two USB interfaces CD-ROM RS-485 – USB adapter Voltmeter **Э545** 3.363.008 Ranges of AC voltage 150V; 300V. Accuracy class 0.5 Autotransformer **ЛАТР (LATR)**
Registration of the verification results	3.5	–

3.4 Verification

3.4.1 External examination

3.4.1.1 Correspondence of the transducer to the following requirements must be determined by external examination procedure:
- absence of mechanical failures of the case, cover, latch and terminals set on the cover;
- well-defined marking;
- presence of a seal and certificate of calibration.

3.4.2 Testing of the insulation resistance

3.4.2.1 For electrical insulation resistance test fixed voltage (500 ± 50) V should be applied between terminal groups connected together in accordance to table 12.

Table 13

Tested circuits	Numbers of terminals connected together		Test voltage (RMS), kV	
	one side	other side	Normal conditions	Highest value of the humidity
Between current and voltage circuits	1-2-3-4-5-6	9-10-11-12	2.5	1.5
Between separate current circuits	1-2	3-4-5-6	2.5	1.5
	3-4	5-6	2.5	1.5
Between the supply and all others circuits	7-8	1-2-3-4-5-6-9-10--11-12-14-15-16--X2 (1-2-3-4)	2.5	1.5
Between input and output circuits	14-15-16-X2 (1-2-3-4)	1-2-3-4-5-6--9-10-11-12	2.5	1.5
Between separate output circuits	X2 (1-2-3-4)	14-15-16	0.5	0.3
Between the case and all circuits	Case*	All	2.5	1.5
* The mounting rail simulator fixed on the latch				

Take megohmmeter readings on expiry of 1 min after voltage test or when readings established.

3.4.2.2 Result of testing is satisfactory if the value of an insulation resistance isn't less than 40 MΩ.

3.4.3 Intrinsic error testing

3.4.3.1 The intrinsic error is defined by a comparison method of measured parameter with a known value parameter reproduced by the standard instrument.

3.4.3.2 Intrinsic error of currents, voltages and powers is defined for three-wire and four-wire connection of the transducer.

3.4.3.3 It is admitted to carry out calibration of intrinsic error only for a measurement mode in which the transducer is used, if there is a decision of the head of a department of calibration or director of firm.

3.4.3.4 The intrinsic error (γ) expressed by formula

$$\gamma = \frac{X_1 - X_0}{X_{nom}} \cdot 100, \qquad (1)$$

X_1 is the value of the measurand calculated by an inverse function of transformation, in measurement unit;

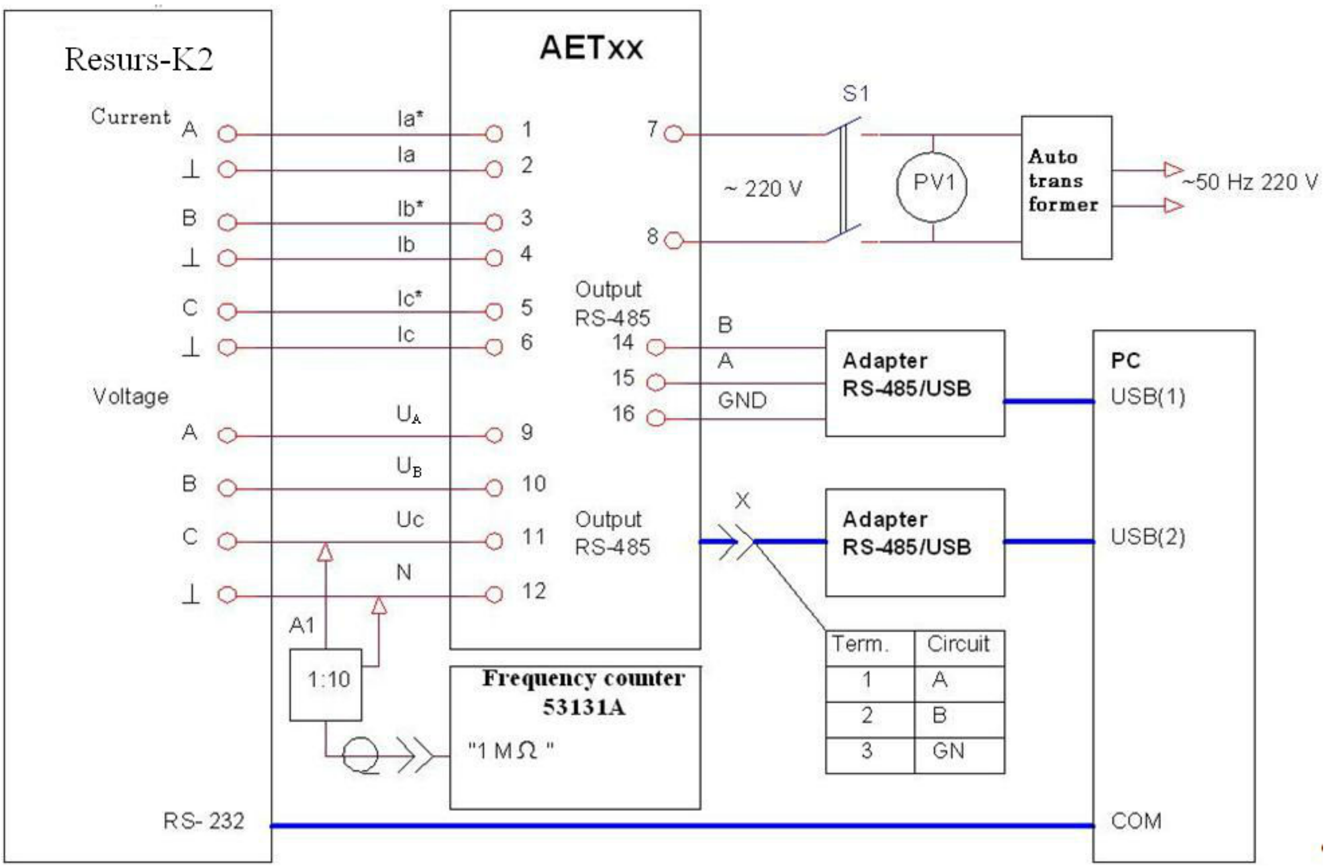
X_0 is the design value of the measurand or the standard instrument value in the test point, in measurement unit;

X_{nom} is the fiducial value of the measurand, in measurement unit.

3.4.3.5 The following operations should be executed before measure:

The workplace for testing of the intrinsic error is made according to a figure 1.

Take megohmmeter readings on expiry of 1 min after voltage test or when readings practically established.



A1 – 1:10 probe device as a unit 53131A frequency counter
PV1 – Э545 Voltmeter
S1 – Double-pole Switch

Figure 1 The working place for testing of the intrinsic error of currents, voltages and powers

- Prepare instruments for operation according to their operation manuals.
- Power up the digital computer. When a load of an operating system is completed, install the application software which is included in a complete set of delivery of the transducer.
- Apply the auxiliary supply to the transducer.
- Start the program "SetComplex 3.1 (EN)", load a configuration file attached to CD:
  - «AET_***_MB.dat» for AETxxx-00 transducer;
  - «AET_***_MB_RTC.dat» for AETxxx-10 transducer;
  - «AET_***_IEC.dat» for AETxxx-01 transducer;
  - «AET_***_IEC_RTC.dat» for AETxxx-11 transducer.
- Configurations are to be install:

Area «RS-485-1» «RS-485-2»	Baudrate, bps	9600
	Stop bits quantity	2
	Parity	NO
	Device address	1
	communication protocol	MODBUS ASCII
Area«Measured parameters»	Registers address	Default set
	Register size, byte	2
	Resolution factor for every measurand k1 k2 k3	 5000 5000 50000
	Group ID	1 (default set)
List «Port»	Any available ones	
List «Memory cell size, byte»	2	
Switch (three-wire system/ four-wire system)	Depending on test type	

- Press the «Write» to confirm the installation of the configurations
- The absence of error messages denotes operability of the transducer.
- Save the configuration of the transducer on the file to the CD.
- Close the «SetComplex 3.1 (EN)» software.

3.4.3.6 The following operations should be executed testing of intrinsic error of the four-wire system:

- Complete the operations in accordance with 3.4.3.5 under four-wire system.
- Start the «ComplexMet 3 EN ». Open the work file at the «Configuration file» menu.
- Configure appropriate parameters in the “RS-485” Menu and «ModBus» Menu.
- Configure appropriate nominal voltage and current values in the «Nom. val» menu in accordance with transducer’s model.
- Press «Start» button in the «ComplexMet 3 EN» window.
- Apply the nominal input signal to the transducer in accordance with 1.2.2.
- Let the transducer standby for 10 minutes before taking the first reading to thermally stabilize.
- Set input signal parameters which are specified in tables by turns:
  - 14, 17 for AET100 transducer;
  - 15, 17 for AET200 transducer;
  - 16, 17 for AET 300 or AET 400 transducers.
- Read the output code at the «ComplexMet 3 EN» and calculate measurand value by inverse function of transformation. In case of alternation of the adjacent codes the most deviating value should be read.

Table 14. Testing signals for AET100 transducer

Voltage, % of the nominal value	Current, % of the nominal value	Current phase relative to the voltage, degree	cos φ
5; 20; 50; 80; 100; 120	100	0	1
100	5; 20; 50; 80; 100; 120	0	1

Table 15. Testing signals for AET200 transducer

Voltage, % of the nominal value	Current, % of the nominal value	Current phase relative to the voltage, degree	cos φ
5; 20; 50; 80; 100; 120	100	0	1
100	5; 20; 50; 80; 100; 120	0	1
120	120	0	1
120	120	180	-1
100	100	60	0.5
		90	0
		150	-0.866
		180	-1
		-120	-0.5
		-90	0
		-30	0.866

Table 16. Testing signals for AET 300, AET 400 transducers

Voltage, % of the nominal value	Current, % of the nominal value	Current phase relative to the voltage, degree	cos φ	sin φ
5; 20; 50; 80; 100; 120	100	0	1	0
100	5; 20; 50; 80; 100; 120	0	1	0
120	120	0	1	0
120	120	180	-1	0
120	120	90	0	1
120	120	-90	0	-1
100	100	60	0.5	0.866
		90	0	1
		150	-0.866	0.5
		180	-1	0
		-120	-0.5	-0.866
		-90	0	-1
		-30	0.866	-0.5
Note- Do not carry out measurements of the Q_{FA}, Q_{FB}, Q_{FC} if phase angle is out-of-range ±(30…150)°				

Table 17. Zero-sequence Voltage and Zero-sequence Current Tests

Voltage, % of the nominal value			Current, % of the nominal value			Phase angle, degree			Current phase relative to the voltage, degree
U_A	U_B	U_C	I_A	I_B	I_C	φ_A	φ_B	φ_C	
100	100	100	100	100	100	0	-120	120	0
50	100	100	50	100	100	0	-120	120	0
0	100	100	0	100	100	0	-120	120	0
100	100	100	100	100	100	0	120	120	0
100	100	100	100	100	100	0	0	0	0

- Set the nominal input signal to the AET400 in accordance with 1.2.2. section; set the frequency of the input signal (45; 50; 55; 60; 65 Hz) by turns; read the output code at the «ComplexMet 3 EN» and calculate frequency value by inverse function of transformation. In case of alternation of the adjacent codes the most deviating value should be read.
- Calculate the intrinsic error (γ) expressed as a percentage of the fiducial value in all check points in conformity with 3.4.3.4.

Limits of the measurand's intrinsic errors are in the table 6.

After the test, switch off the input signal source, press the «Stop» button in the «ComplexMet 3 EN» window. End the program «ComplexMet 3 EN» and then cut off the auxiliary supply.

3.4.3.7 The following operations should be executed testing of intrinsic error of the three-wire system:

- Complete the operations in accordance with 3.4.3.5 under three-wire system.
- Start the «ComplexMet 3 EN». Load the work configuration file at the « File» menu.
- Configure appropriate parameters in the «RS-485» Menu and «ModBus» Menu.
- Configure appropriate nominal voltage and current values in the «Nominal value» Menu in accordance with transducer's model.
- Press "Start" button in the «ComplexMet 3 EN» window.
- Apply the nominal input signal to the transducer in accordance with 1.2.2.
- Let the transducer standby for 10 minutes before taking the first reading to thermally stabilize.
- Set input signal parameters which are specified in tables by turns in accordance with 14, 15 or 16 tables. Read the output code at the «ComplexMet 3 EN» and calculate measurand value by inverse function of transformation. In case of alternation of the adjacent codes the most deviating value should be read.
- Calculate the intrinsic error (γ) expressed as a percentage of the fiducial value in all check points in conformity with 3.4.3.4

Limits of the measurand's intrinsic errors are in the table 6.

After the test, cut off the input signal source, press the «Stop» button in the «ComplexMet 3 EN» window. End the program «ComplexMet 3 EN». Next, cut off the auxiliary supply.

3.4.3.8 The relative value of a ratio between an aggregate error of a standard and the intrinsic error of the gauged transducer should not exceed 1/3.

The greatest adoption probability of the unsuitable transducer as suitable is 0.1.

The greatest permissible value of the ratio transducer's intrinsic error to a limit of the supposed intrinsic error is 1.2, when the unsuitable transducer is adopted as suitable.

3.5 Registration of verification result

3.5.1 The results of testing are put down into the protocol in accordance with Annex E.

3.5.2 The results of the verification are the validation of the transducer or the statement of unworthiness of the transducer.

3.5.3 If the transducer is recognized as valid, the calibration stamp must be plotted at the passport or the certificate of calibration must be granted.

3.5.4 If the transducer is recognized unsuitable for use by results of verification, the notification on unworthiness must be written. In case of periodic verification, the calibration stamp (if its presence) must be suppressed; the previous certificate of calibration must be nullified.

4 Maintenance and repair

4.1 General maintenance

4.1.1 The field inspection for transducer operation should be carried by persons, who have the responsibility for this equipment.
4.1.2 The transducer should not be opened during operation.
4.1.3 The manufacturer eliminates all defects originating during operation.

4.2 Safety

4.2.1 The qualified personnel should execute operations of maintenance.
4.2.2 The transducer corresponds to the IEC 61010-1:2001 (ГОСТ Р 52319-2005).

⚠ 4.2.3 WARNING! THE INPUT AND SIGNAL TERMINALS COULD BE ALIVE (UNDER THE HIGH VOLTAGE).
TO AVOID THE ELECTRICAL SHOCK IT IS FORBIDDEN: TO CHANGE EXTERIOR CONNECTIONS, WHEN INPUT SIGNAL IS APPLIED TO THE TRANSDUCER.

4.3 Order of maintenance

4.3.1 It is recommended to carry out routine testing in field quarterly. For this purpose:
- turn the input signal and auxiliary supply off;
- remove dust from case;
- test a condition of the case; to be convinced of absence of mechanical failures; to test a condition of mounting;
- turn the input signals and auxiliary supply on.

4.3.2 If the transducer is mounted on the rail you can carry demounting. Insert a screwdriver into a recess in the bottom of the case and release a latch.

4.4 Metrology monitoring

4.4.1 To confirm real values of the metrology characteristics and availability of the transducer to application, it can be exposed to verification (calibration) according to section 3 of the present manual, which was matched with ВНИИМС (Russian Research Institute for Metrological Service).
Recalibration interval is 7 year.

5 Storage

5.1 Before commissioning the transducer should be stored in storehouses according to ГОСТ Р 52931.

5.2 Storage conditions for transducers in transport container:

- Ambient Air Temperature .... 5 to 40 °C;
- Relative Humidity at 25 °C .... up to 80 %.

5.3 Storage conditions for transducers in individual packing:

- Ambient Air Temperature .... 10 to 35 °C;
- Relative Humidity at 25 °C .... up to 80 %.

5.4 The presence of a dust, steams of acids and alkalis, aggressive gases and other harmful admixtures resulting corrosion should not exceed the contents of the corrosion-active agents for the atmosphere of a type 1 (ГОСТ 15150-69).

6 Transportation

6.1 Transducers could be transported in transport container in the closed vehicles of any type.
Transducers should be disposed in heated hermetic bays when air transporting.

6.2 Values of climatic and mechanical effects on the transducer at transportation should be in limits:

- Ambient Air Temperature .... - 50 to 55 °C;
- Relative Humidity at 35 °C .... up to 95 %;
- Atmospheric pressure, kPa (mm Hg) .... 84-106 (630-800).
- Vibration is defined as group N2 by ГОСТ 52931 when vehicle or air transportation.

Annex A
(informative)

General Form of the transducer

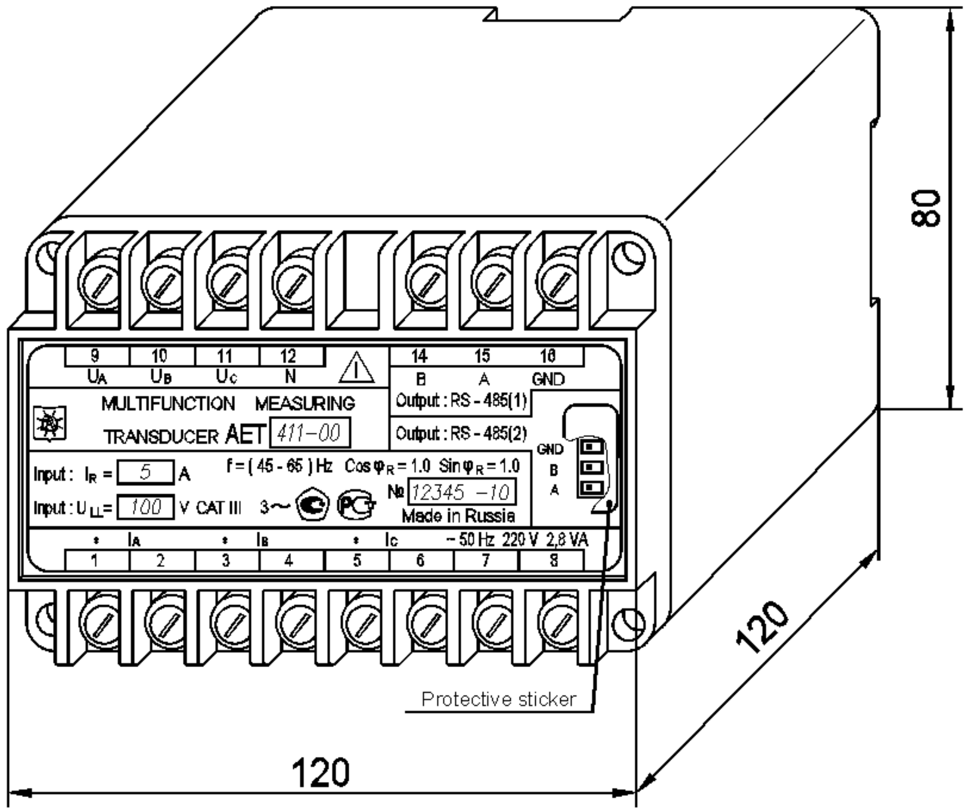


Figure A.1

Annex B
(informative)

"SetComplex 3.1 (EN)" Description

B.1 The «SetComplex 3.1 (EN)» software is intended for the AET100, AET200, AET300, AET400 Multifunction Measuring Transducer configuration. There are two RS-485 independent interfaces «RS-485(1)» and «RS-485(2)».

The software permits to install such settings as:

1) COM-port number
2) RS-485 data exchange parameters:
   - rate of exchange;
   - stop bits quantity;
   - parity;
   - device address;
   -communication protocol
   - Memory cell size;
   - ASDU size;
   - «Cause of transmission» field size
   - ASDU receive data type;
   - Mode of operation;
3) Measurement mode (3-Wire/4-Wire).
4) Registers of the measured parameters
   -register address;
   - register size;
   - resolution factor for every register;
   - ID group number;
5) External indication device
   - transformation ratio of a voltage transformer (K_U);
   - transformation ratio of a current transformer (K_I);
   - reduction set point;
   - growth set point;

The «About SetComplex 3.1 (EN)» menu contains common information of the software and its version.

B.2 Main operation

B.2.1 Software installation

B.2.1.1 Insert the software CD is enclosed to the transducer. Open the folder : \«Документация и программное обеспечение»\ «Preob AET»\. Copy the «Programs» folder to the work disk.

B.2.1.2 Connect the «RS-485(2)» transducer interface to USB computer interface by «RS-485 – USB» adapter.

B.2.1.3 Switch the supply voltage to the transducer.

B.2.1.4 To launch the software open the executable file «SetComplex 3_1.exe» form the «Programs» directory.

The form of the main program window is shown at the B.1 figure.

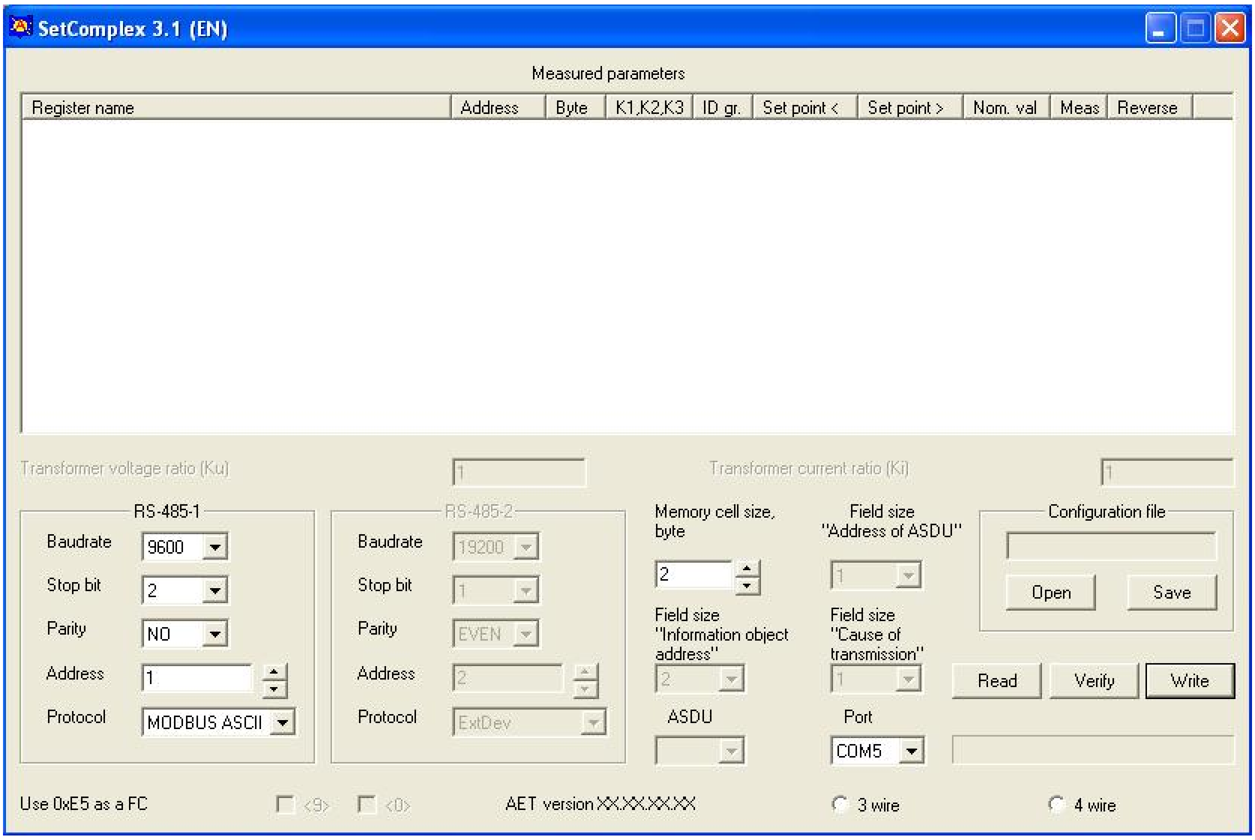


Figure B.1

B.2.2 Reading of the current transducer configuration

B.2.2.1 Select the COM-port connected to the transducer from the list «Port».

B.2.2.1 Press the «Read» button to read the transducer configuration. The current configuration is shown at the main program window.

The form of the main window with AET400 configuration file is shown at the B.2 figure.

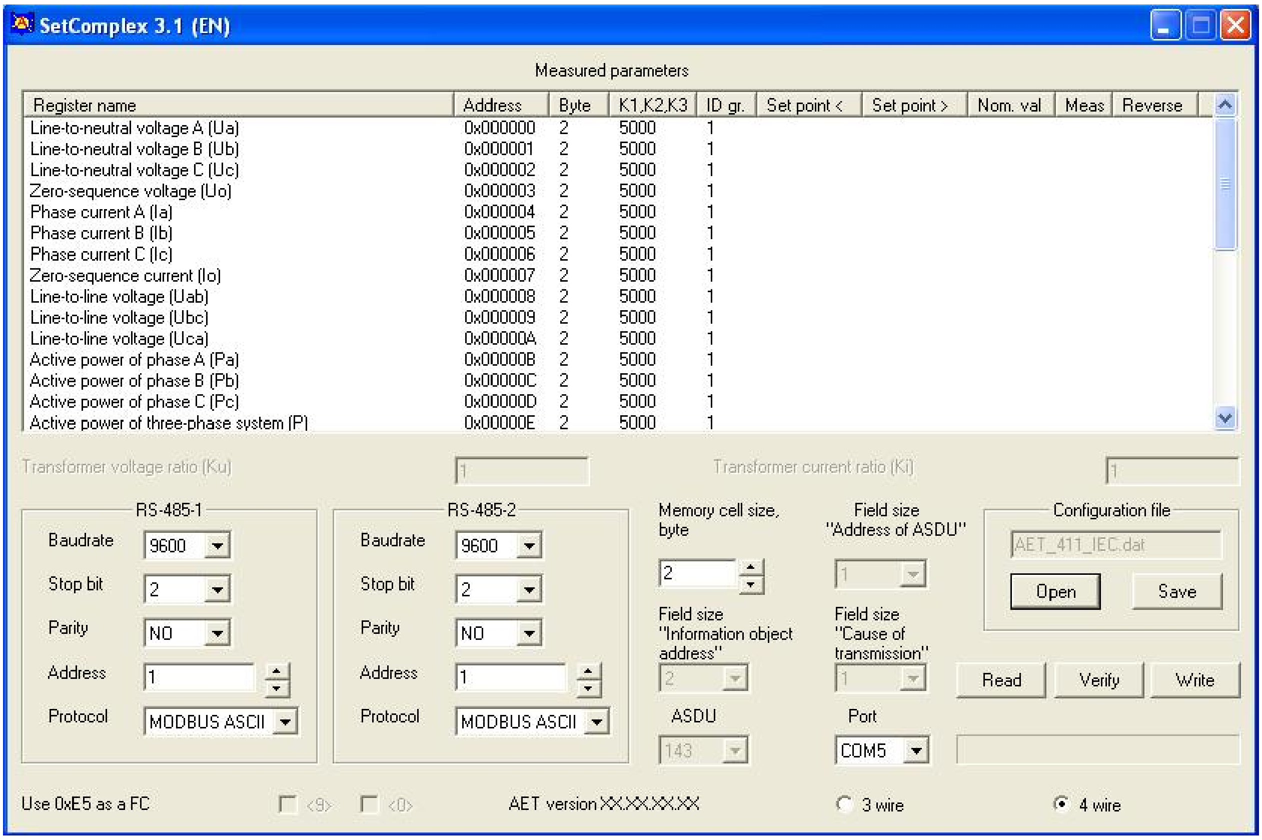


Figure B.2

B.2.2.3 Error notification appears in case of incorrect COM-port. Select the correct COM-port and press the «Read» button iteratively.

B.2.3 Setting of the data exchange parameters by RS-485.

B.2.3.1 Set the requisite RS-485 transducer interfaces parameters at the appropriate areas.

- choose the communication protocol from the «Protocol» list at the «RS-485-1» area: «MODBUS ASCII», «MODBUS RTU», «IEC-101».
- choose the communication protocol from the «Protocol» list at the «RS-485-2» area: «MODBUS ASCII», «MODBUS RTU», «IEC-101», «ExtDev» (The form of the window appearance of the AET400 transducer configuration file with «IEC-101» communication protocol is shown at the B.3 figure).

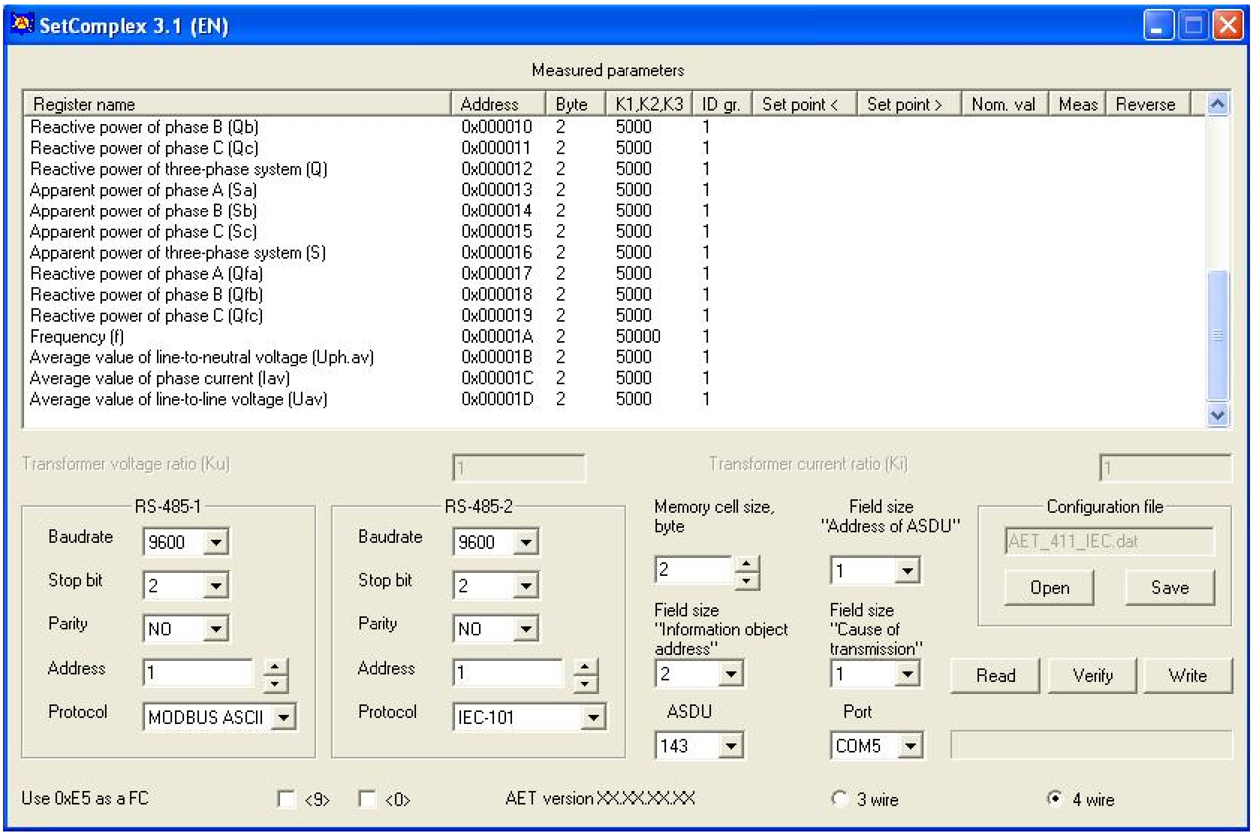


Figure B.3

Set the installed transducer address to the « RS-485-1» and «RS-485-2» areas.

The default address is «1».

B.2.3.2 The «Memory cell size, byte» area defines the address quantity in one register (Address quantity = Register size / Memory cell size). The address quantity is a round up integer number.

B.2.3.3 The «Field size «Address of ASDU», «Field size «Information object address», «AS-DU», «Field size «Cause of transmission» lists and check-boxes at the «Use 0xE5 as a FC» area are available when the «IEC-101 communication protocol is chosen.

The «Field size «Address of ASDU» list is intended to choose the general ASDU address size of 1 or 2 bytes.

The «Field size «Cause of information» list is intended to choose the address size of the object to be tested of 1, 2 or 3 bytes.

B.2.3.3 The «ASDU» list contains available data blocks (9, 10, 21, 143).

The «Field size «Cause of transmission» list is intended to choose the area size of 1 or 2 bytes.

The «Use 0xE5 as a FC» check-boxes are intend to change the functional code FC< 9 >, FC< 0 > data link layer.

B.2.4 Measurement mode setting

B.2.4.1 The transducer measurement mode is selected between three-wire and four-wire connection by «3-wire/4-wire» switch.

B.2.5 Data register setting

B.2.5.1 The «Measured parameteres» area contains the list of the each measurand with relevant register address, register size (byte), resolution factor (k1, k2 or k3).

When «3-wire» mode is applied, irrelevant parameters are marked red.

B.2.5.2 Measuring current and voltage values k1 factor should be set ranging from 2500 to 5000; measuring power values k2 factor should be set ranging from 1000 to 5000; measuring frequency values k3 factor should be set ranging from 20000 to 50000.

B.2.5.3 To edit the measurement parameters properties open the «Property» dialog box.

To open Property dialog box, select and double-click the left mouse button an editing parameter in the «Measured parameters» area. Edit a resolution factor, ID group number, register address and its size in the pop-up menu if it’s necessary. The form of the property dialog box for line-to-neutral voltage is given in Figure B.4

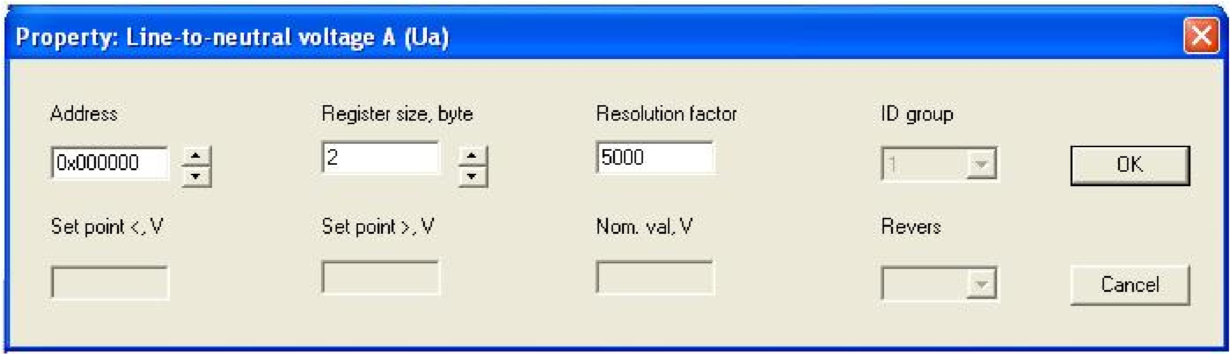


Figure B.4

To save a selected configuration, press the «OK» button. Changes will be represented in the program main window.

B.2.6 Setting parameters to interaction with external indication device.

B.2.6.1 The form of the dialog box when communication protocol «ExtDev» is selected for «RS-485-2» interface is given in Figure B.4 (example for AET411 transducer).

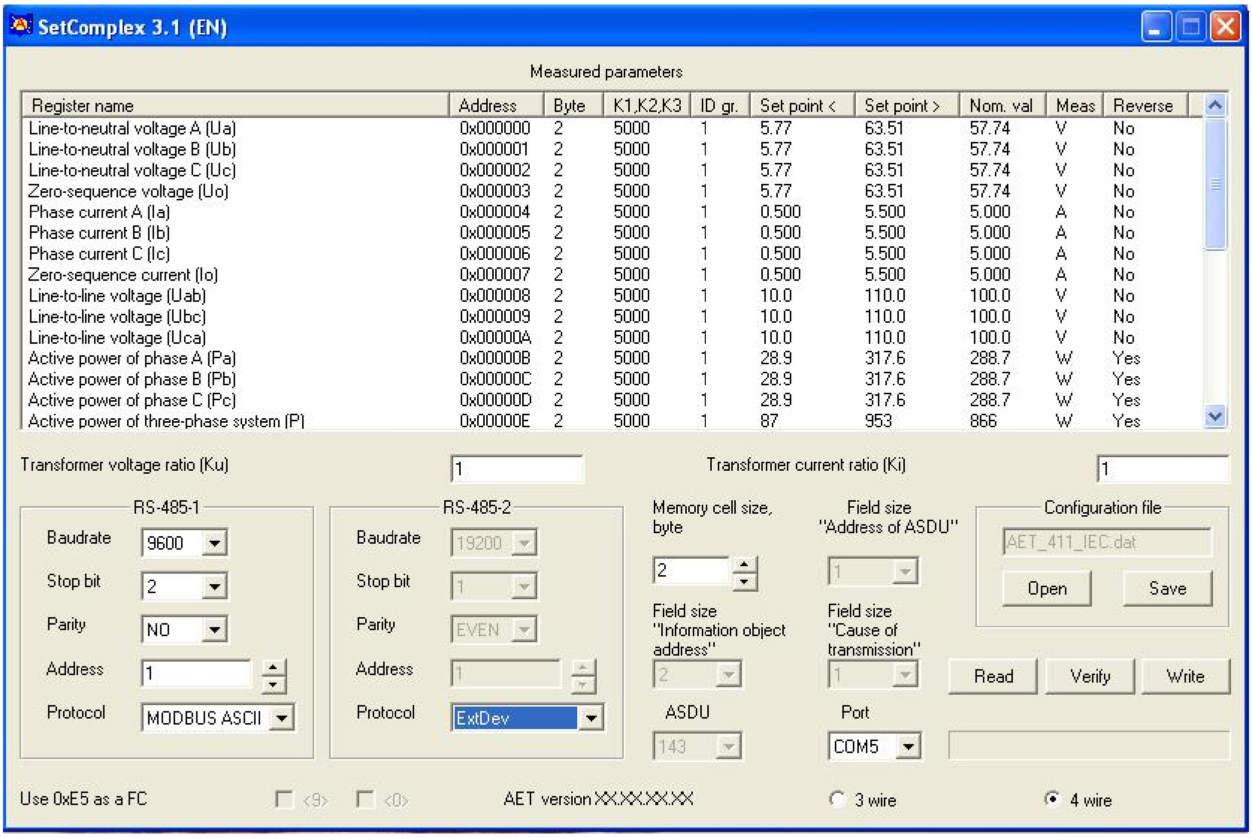


Figure B.5

B.2.6.2 The «ExtDev» protocol is intended to incessant transmission (without enquiry message) of the measurement data by «RS-485(2)» interface to the external indication device. External indication device is supplied on separate order.

- AED is the seven-segment display indication device. It indicates three selected parameters and set points (30 devices into one transducer maximum).
- AEGD is the indication device performed on the graphic display. It indicates three snapshots with eight selected parameters alternately.

The external indication device image the data by way of four-digit decimal number corresponds to measurand expressed in measurement unit. The updating rate of data is 3 Hz.

B.2.6.3 Enter the transformation ratio of a voltage transformer (K_U) by keyboard at the «Transformer voltage ratio (K_U)» area and push the «Enter» button. The value of the K_U should be integer. The default value is $K_U = 1$.

B.2.6.4 Enter the transformation ratio of a current transformer K_I by keyboard at the «Transformer current ratio (K_I)» area and push the «Enter» button. The value of the K_I should be integer. The default value is $K_I = 1$.

B.2.6.5 After transformation ratio data entry the program is calculating nominal values. Calculated values and the measurement units are indicated at the «Measured parameters» area. The form of the program window with K_U=1100 and K_I=120 is shown at the figure B.6.

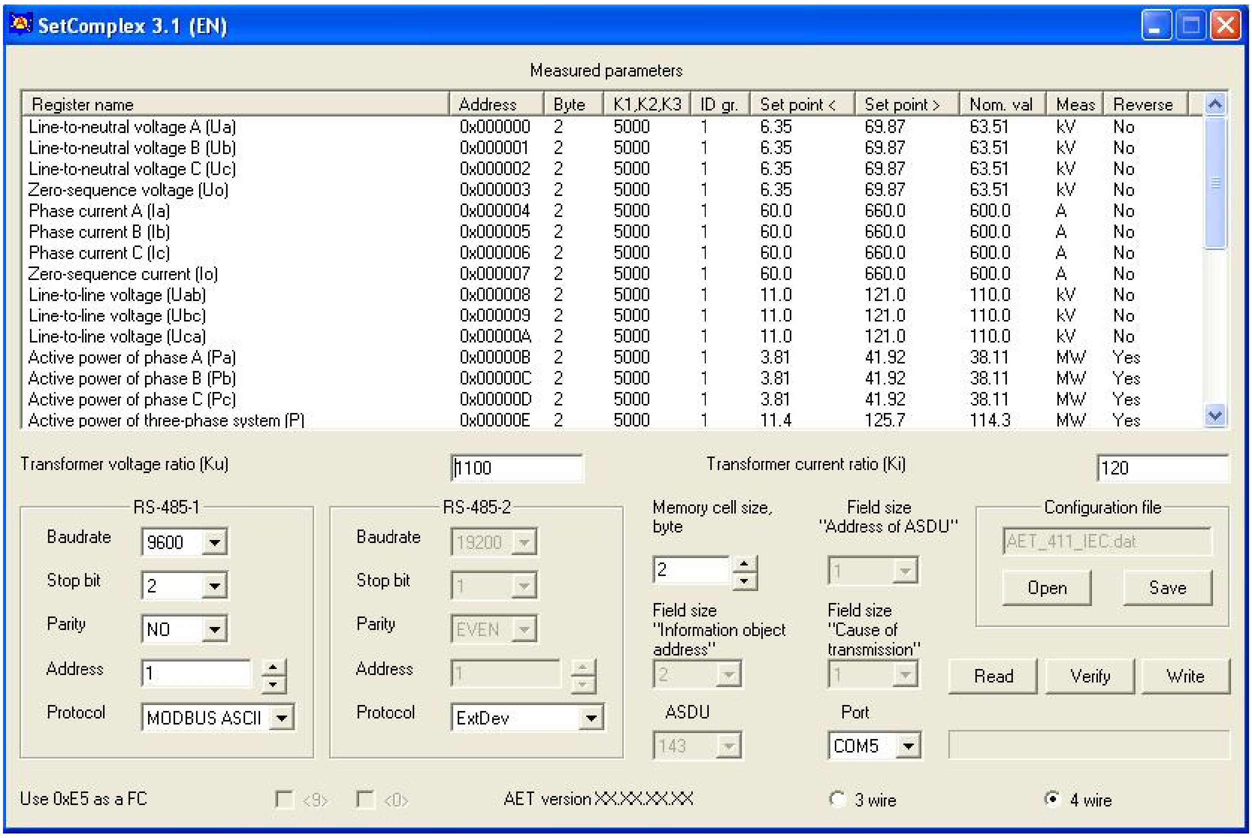


Figure B.6

B.2.6.6 The «Set point < » and «Set point > » columns at the «Measured parameters» table reflects the transducer configuration to be sent to the AED indication device nominal value. The default reduction set point is 0,1 relating to the nominal value of the measurand. The default growth set point is 1,1 relating to the nominal value of the measurand.

When the measurand is less than set point, the « < » sign is indicated rightwards of the indicating value.

When the measurand is more than set point, the « > » sign is indicated rightwards of the indicating value.

When the measurand is between set points, the signs aren’t indicated.

B.2.6.7 To edit set points of measurand open the «Property» dialog box. To open Property dialog box, select and double-click the left mouse button on editing parameter in the «Measured parameters» area.

Edit set points at the «Property» area. Enter the reduction set point at the «Set point < » area using, the relevant measurement unit. Enter the growth set point at the «Set point > » area, using the relevant measurement unit. The form of the property dialog box for phase current is given in Figure B.7

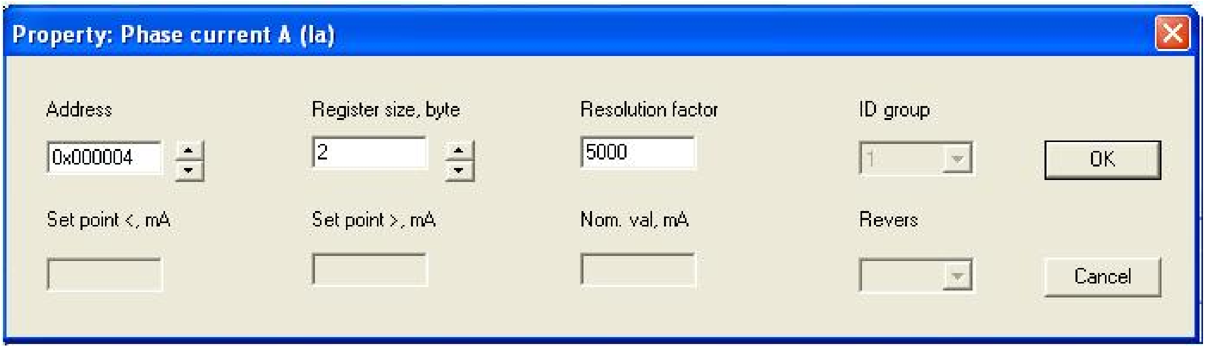


Figure B.7

To save a selection, press the «OK» button. The introduced data is displayed at the main program menu.

Notification - the information about activities with «Revers» table column isn't described in this operation manual. This table column is reserved.

B.2.6.8 The «SetIndikator» and «SetDisplay» software are used to configure external indication device. The maintenance documentation for the indication device contains the description about these software products.

B.2.7. Configuration save

B.2.7.1 Press the **«Write»** button in the program main window to save the configuration has been set. The activation of the button causes the «Password entry» pop-up menu. The form of the program window is shown at the B.8 figure.

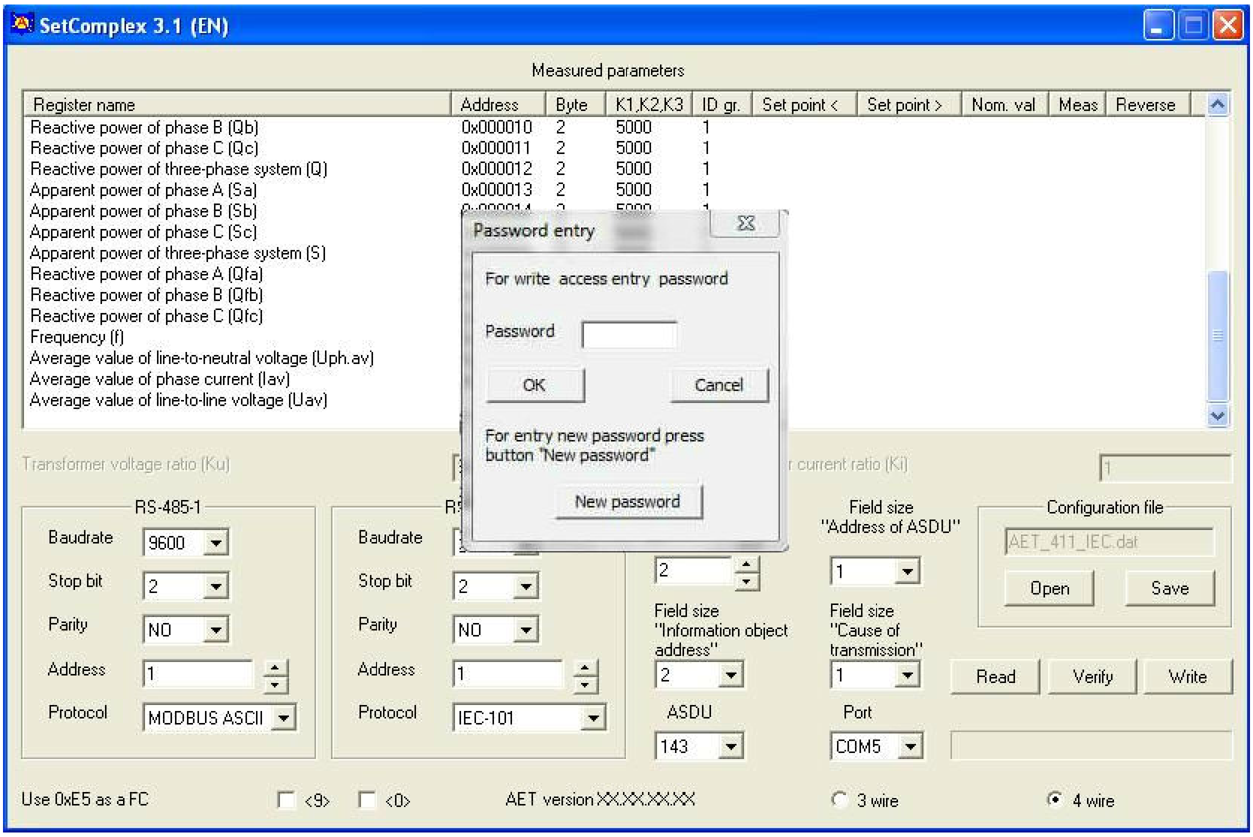


Figure B.8

To save the configuration, enter the password (5 symbols) and press the «OK» button. The default password is «12345».

If password is correct, the process of saving will start. When the process is completed, the «Data record has passed successfully» message will be appeared. Press the «OK» button to end saving.

B.2.7.2 To change password, press the «Write» button, then click on the «New password» button and execute program proposed actions.

If you lose your password, contact the manufacturer for further instructions. Contacts are specified in the transducer's passport.

B.2.7.3 The «Verify» button starts the verification of the saved configuration. If the verification is passed the «Check data has passed successfully» message is appeared.

B.2.7.4 To save the working configuration file in memory, press the «Save» button at the «Configuration file» area, then perform all necessary actions in the saving file window that appears.

B.2.8 Reset transducer to factory setting

B.2.8.1 To reset a transducer to factory setting perform following procedures: press the «Open» button at the «Configuration file» area by mouse double-click. Open and load the factory setting file. The factory setting files are contented in the «Programs \ Data» folder and represented as:

- cooperative with MODBUS connection protocol:

«AET_***_MB.dat» for AETxxx transducer without timestamp.

«AET_***_MB_RTC.dat» for AETxxx transducer with timestamp.

- cooperative with IEC 60870-5-101 connection protocol:

«AET_***_IEC.dat» for AETxxx transducer without timestamp.

«AET_***_IEC_RTC.dat» for AETxxx transducer with timestamp.

For example, «AET_411_IEC_RTC.dat» file corresponds to AET411 transducer, IEC 60870-5-101 communication protocol and timestamp option.

B.2.8.2 After file loading a factory setting will be displayed at the main program window and name of the chosen file will be displayed at the information field of the «Configuration file» area.

B.2.8.3 To save a factory setting, press the «Write» button and enter the password.

If password is correct, the process of saving will start. When the process is completed, the «Data record has passed successfully» message will be appeared. Press the «OK» button to end saving.

Annex C
(informative)

"ComplexMet 3 EN" Description

C.1 Introduction

The «ComplexMet 3 EN» program is intended for the displaying and saving of the AET transducer output data by RS-485 interface.

All information about program is contained at the «About ComplexMet 3 EN» window that is invoked from the program heading.

C.2 Installation

C.2.1 To install the program, insert the CD, that is enclosed to the transducer. Open the «Preob AET» folder, find and copy the «Programs» folder to the PC location you wish. From this moment on reference to «Programs» folder, that is on the PC.

C.3 Program window description

C.3.1 The form of the main program window is shown at the B.1 figure.

The program window consists of entitle, main menu and working area.

C.3.2 The program menu contains the following option:

- «File»;
- «RS-485»;
- «ModBus»;
- «IEC-101»;
- «Nominal value».

The «File» Menu is intended to open the configuration file.

The «RS-485» Menu is intended to choose the parameters of the RS-485 interface.

- «Parity»;
- «Stop
- «Baudrate»;
- «Port»..

The «ModBus» menu is used to preset a device address and ASCII/ RTU mode.

The «IEC-101» menu is used to set such parameters as device address and sizes of the fields «Address of ASDU», «Information object address», «Cause of transmission».

The «Nominal value» menu is used to set a nominal current value, a nominal line-to-line value are specified for the tested transducer.

The «ModBus» and «IEC-101» radio buttons are intended to choose appropriate connection protocol.

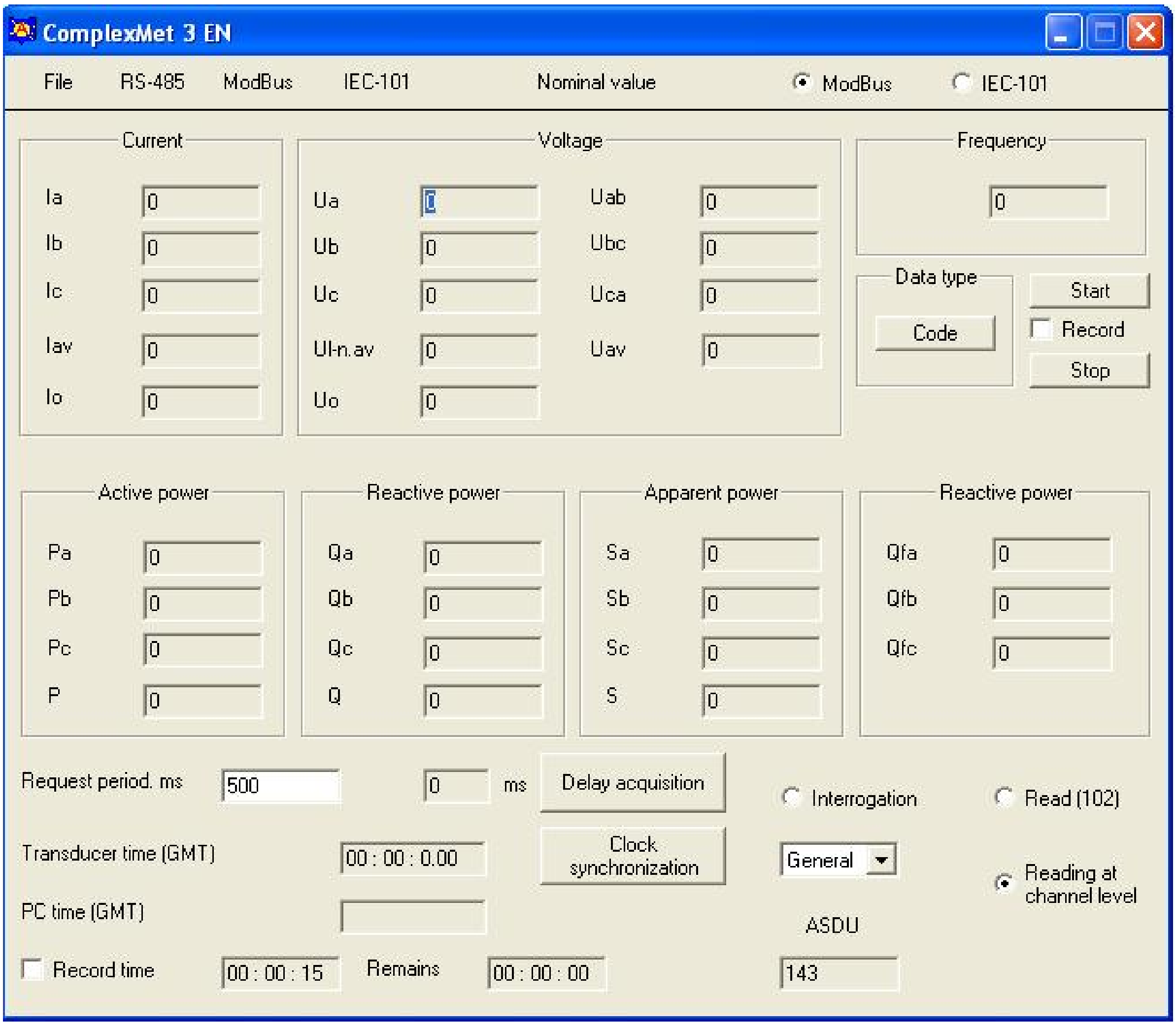


Figure B.1

C.3.3 The working area of the main program menu consists of :
-The working area shows the actual values of the measurand:
- Current;
- Voltage ;
- Frequency;
- Active power;
- Reactive power;
- Apparent power;
- Reactive power (modulus)

Note: Depends on transducer type and measurement mode some parameters could be not measured, in this case such parameters are dimmed.

- Data format area - «Data type»; Data format is selected under the re-pressed Button located in the data type area. If the «Code» button position is active, all measurand are in the numerical code. When the « Phys. unit.» button position is active, all measurand are in measurement units.
- «Start» and «Stop» Buttons;
- «Record» check-box is ticked to save data;
- Recording time;
- «Request period, ms» is the information field, that indicates period of the transducer sampling. The default value of the period sampling is 500 ms, the minimal value is 50 ms.
- Information fields: «Transducer time (GMT)», «PC time (GMT)».

- «Record time» check-box. The ticked check-box allows to set a run time of the data recording.
- «Remains» field. Information field displays the remaining data recording time.
- «Clock synchronization» button (time synchronization).
- «Delay acquisition» button is intended to activate the delay time procedure, when «IEC» protocol is applied.
- «Interrogation», «Reading at channel level» and «Read (102)» radio buttons control the query function by «IEC-101» communication protocol.
- «General» list is tied to «Interrogation» radio button. The list of the available groups is given.
- «ASDU» information field displays active ASDU, when «IEC-101» protocol is applied.

C.4 Main operation

C.4.1 Using «RS-485 – USB» adapter, connect the one of the RS-485 interfaces of the transducer to the computer.

C.4.2 Apply the auxiliary supply to the transducer. Apply the input signal to the transducer.

C.4.3 Start the «ComplexMet 3 EN». Select the appropriate connected interface from the «Port» list in the «RS-485» menu.

C.4.4 Load the work configuration file at the “File” menu. Appeared program window displays the configurations of the RS485(1) transducer interface.

To operate with RS485(2) interface set relevant data exchange parameters. Parameters must correspond to transducer configuration.

C.4.5 Open the «Nominal value» menu. Select the values for the transducer at the «Nominal line voltage, V» list and «nominal current, A» list.

C.4.6 To start the receiving data from the transducer press the «Start» button. The processing data will be displayed at the program window.

To stop the data receive press the «Stop» button.

C.4.7 To save the received data tick the check-box at the «Record». A data file will be saved into C:\ ComplexTXT.

To stop the data record press the «Stop» button.

To programming stop of the recording tick the «Record time» check-box and set the actuation time by «hh mm ss» (hours, minutes, seconds) at the relevant field.

Annex D
(informative)

Variants of transducer mounting

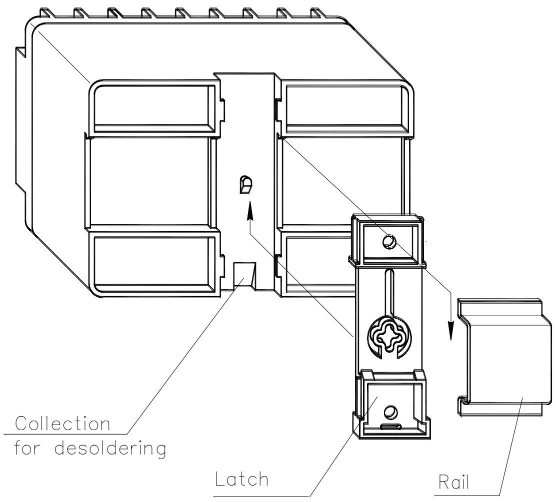


Figure D.1 Mounting on the Rail

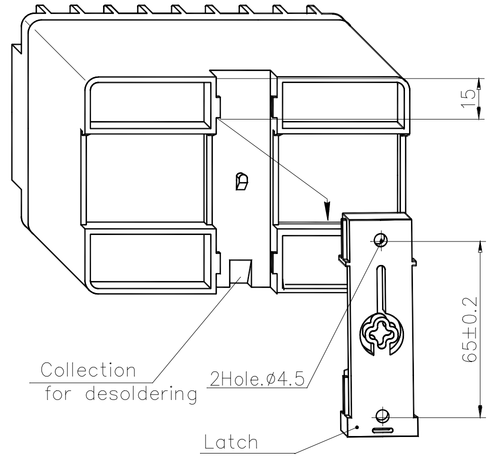
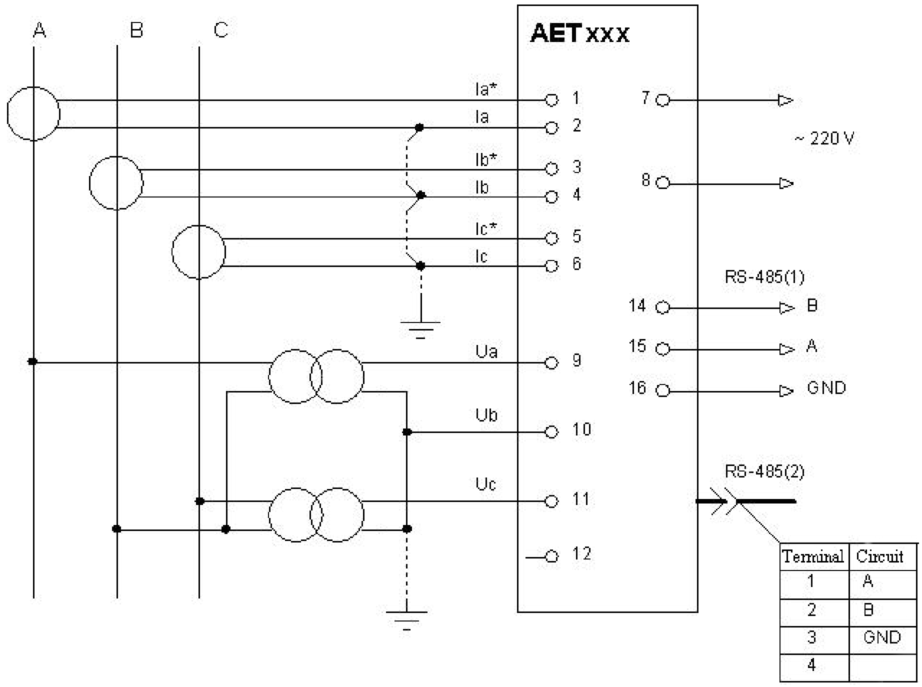


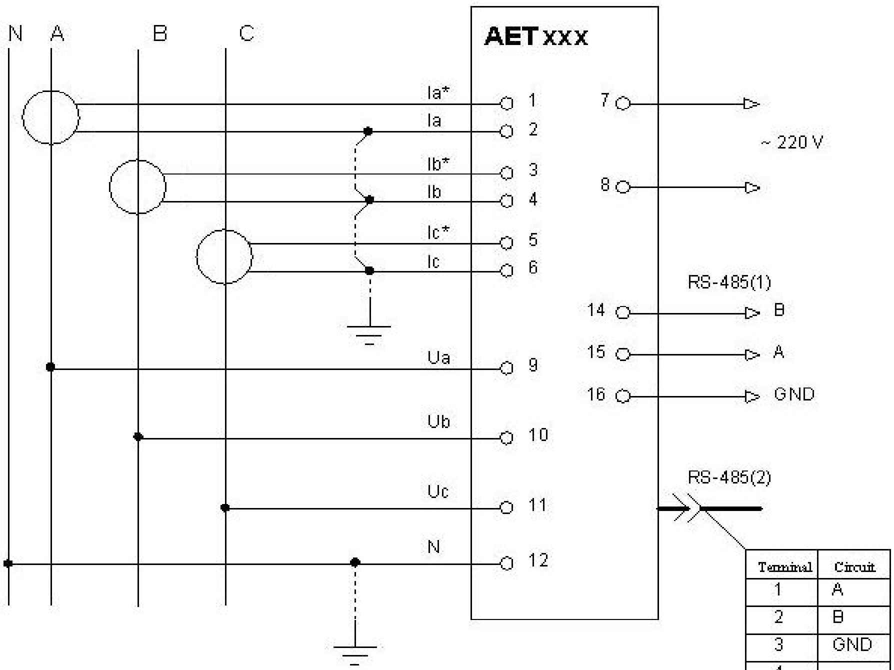
Figure D.2 Mounting on the Panel

Annex E
(informative)
Diagrams of transducer connections



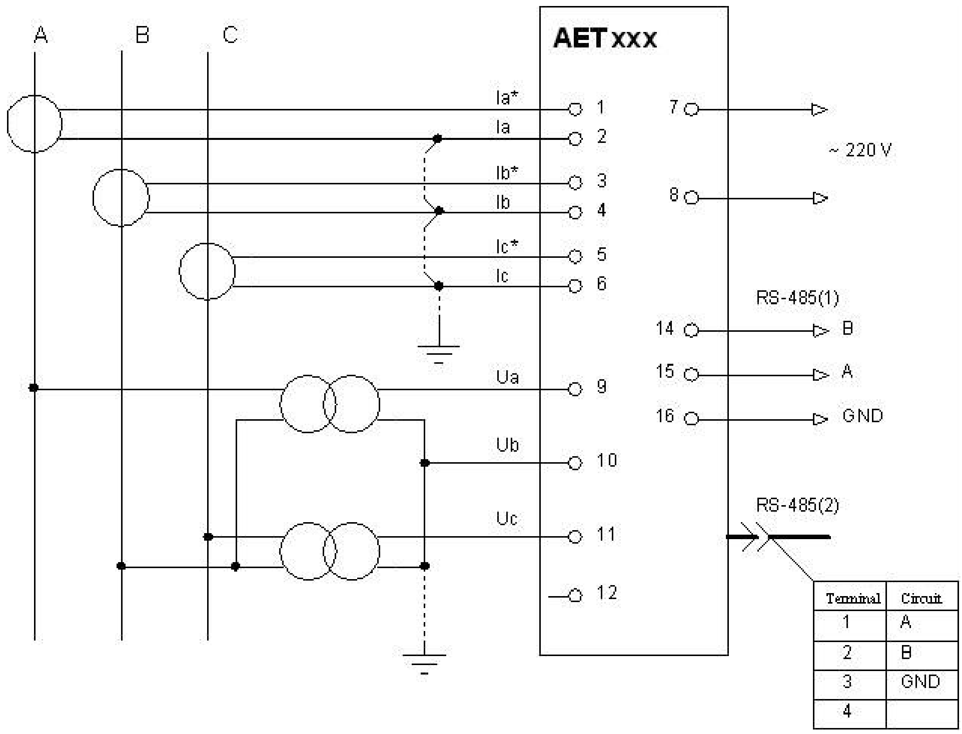
Note: connection, implemented by dotted line, could be absent.

Figure E.1. Four-wire connection with voltage transformers



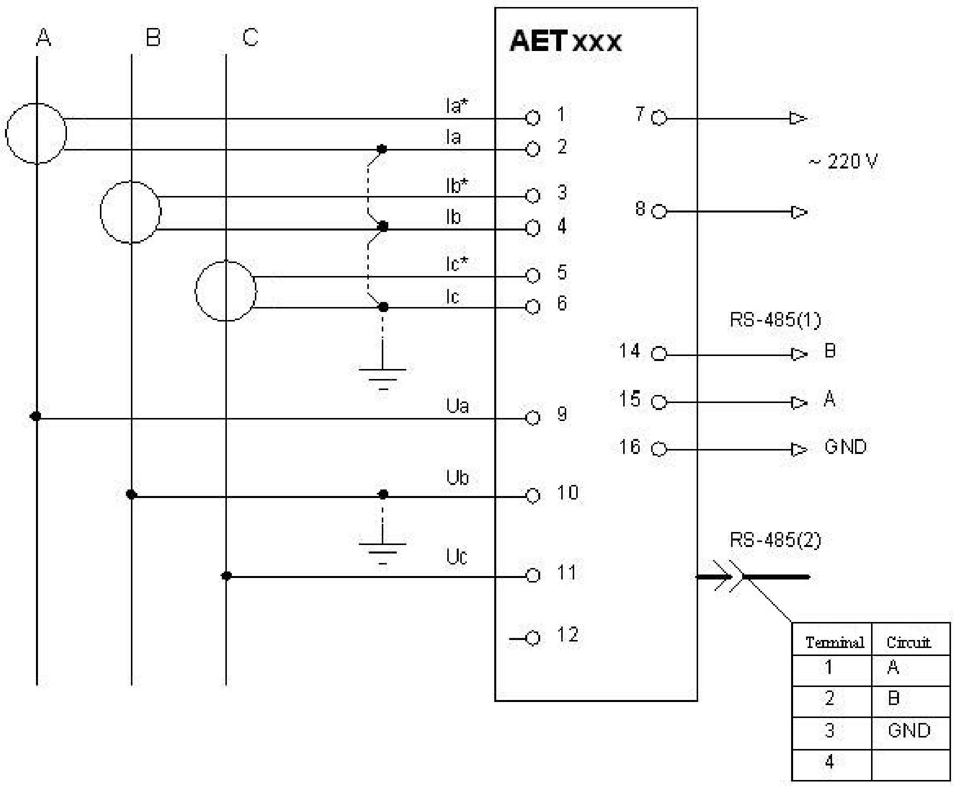
Note: connection, implemented by dotted line, could be absent.

Figure E.2. Four-wire connection without voltage transformers



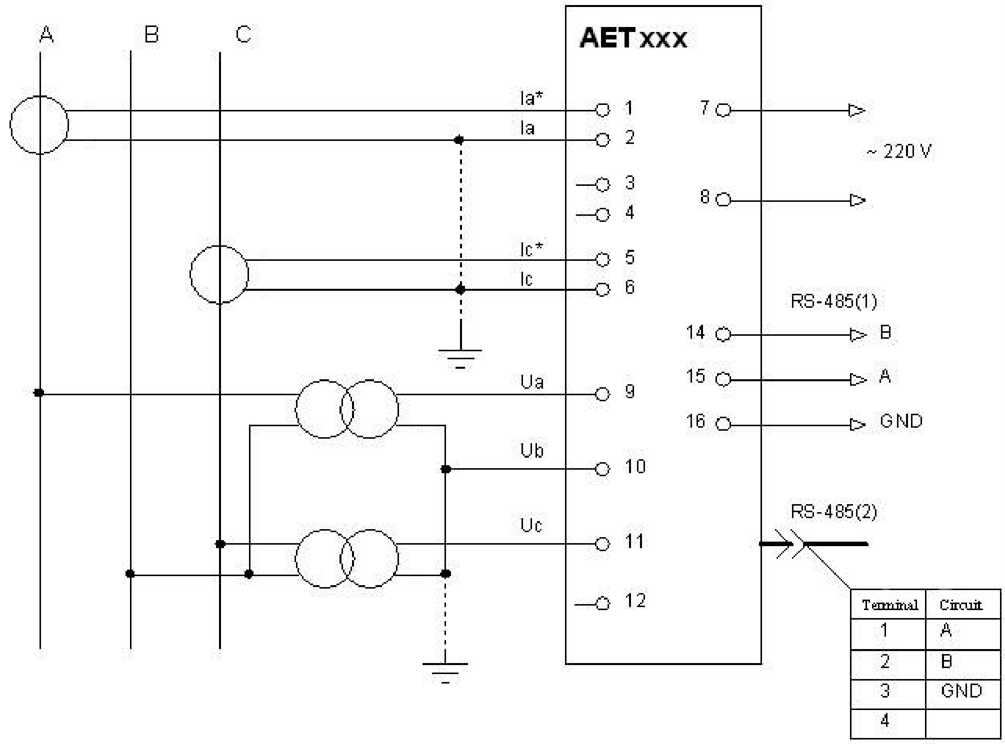
Note: connection, implemented by dotted line, could be absent.

Figure E.3. Three-wire connection with voltage transformers



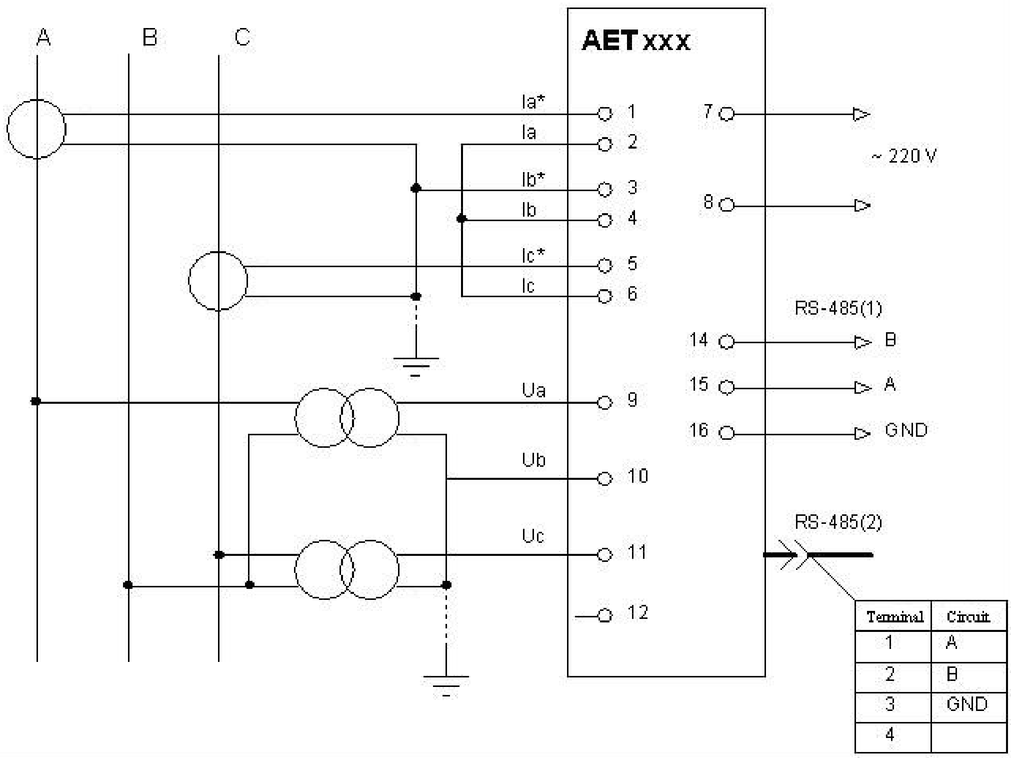
Note: connection, implemented by dotted line, could be absent.

Figure E.4. Three-wire connection without voltage transformers



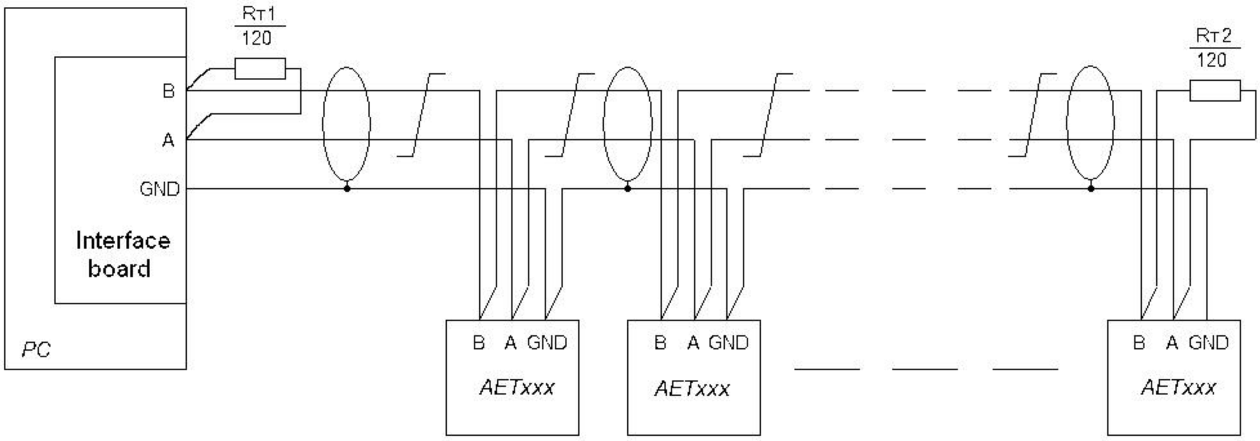
Note: connection, implemented by dotted line, could be absent.

Figure E.5. Three-wire connection with two voltage transformers and two current transformers



Note: connection, implemented by dotted line, could be absent.

Figure E.6. Three-wire connection with two voltage transformers and two current transformers(phase B current measurement)



R_T1, R_T2 – Resistor C2-33-0,25 W –120 Ω ± 5%
Wire section is no less than 0,2 mm^2

Figure E.7. RS-485 interface connection

Annex F

The form of the calibration protocol of the transducer

Protocol of calibration

Transducer ____________ №__________, Inhering ________________________________
Type Serial number The name of firm

is verified by ____ ________________ .
The name of firm making verification Year, month, date

F.1 Calibration condition

Ambient Air Temperature ________________________________°C
Relative Humidity_______________________________________%
Atmospheric pressure ____________________________________kPa
Supply frequency _______________________________________Hz
Supply voltage ____V

F.2 Used means ____

____

____

F.3 External examination

Result ____

F.4 Insulation resistance test

Result ____

F.5 Verification Tests

F.5.1 Line-to-line Voltage Tests (4-Wire)

Check point U_{AB0} (U_{BC0}, U_{CA0}), V	Transducer under test reading U_{AB1}		Intrinsic error γ, %	Transducer under test reading U_{BC1}		Intrinsic error γ, %	Transducer under test reading U_{CA1}		Intrinsic error γ, %	Transducer under test reading U_{AV}		Intrinsic error γ, %
	Output code	Value, V		Output code	Value, V		Output code	Value, V		Output code	Value, V	
$U_{L-L\ nom}$ =____________ k1 = __________												

Conclusion:____

F.5.2 Line-to-neutral Voltage Tests (4-Wire)

Check point U_{A0} (U_{B0}, U_{C0}), V	Transducer under test reading $\mathbf{U_{A1}}$		Intrinsic error γ, %	Transducer under test reading $\mathbf{U_{B1}}$		Intrinsic error γ, %	Transducer under test reading $\mathbf{U_{C1}}$		Intrinsic error γ, %	Transducer under test reading $U_{L\text{-}N\cdot AV}$		Intrinsic error γ, %
	Output code	Value, V		Output code	Value, V		Output code	Value, V		Output code	Value, V	
$U_{L\text{-}N\ nom}$ =_____________ k1 = ___________												

Conclusion: ____

F.5.3 Current Tests (4-Wire)

Check point I_{A0} (I_{B0}, I_{C0}), A	Transducer under test reading $\mathbf{I_{A1}}$		Intrinsic error γ, %	Transducer under test reading $\mathbf{I_{B1}}$		Intrinsic error γ, %	Transducer under test reading $\mathbf{I_{C1}}$		Intrinsic error γ, %	Transducer under test reading $\mathbf{I_{AV}}$		Intrinsic error γ, %
	Output code	Value, A		Output code	Value, A		Output code	Value, A		Output code	Value, A	
I_{nom} =_____________ k1 = ___________												

Conclusion: ____

F.5.4 Zero-sequence Voltage Tests (4-Wire)

Check point $\mathbf{Uo_{(0)}}$. **B**	Transducer under test reading $\mathbf{Uo_{(1)}}$		Intrinsic error γ, %
	Output code	Value, V	
$U_{L\text{-}N\ nom}$ =_____________ k1 = ___________			

Conclusion: ____

F.5.5 Zero-sequence Current Tests (4-Wire)

Check point $Io_{(0)}$, A	Transducer under test reading $Io_{(1)}$		Intrinsic error γ, %
	Output code	Value, A	
I_{nom} =____________ k1 = __________			

Conclusion: ____

F.5.6 Active Power Tests, per phase (4-Wire)

Check point				Transducer under test reading P_{A1}		Intrinsic error γ, %	Transducer under test reading P_{B1}		Intrinsic error γ, %	Transducer under test reading P_{C1}		Intrinsic error γ, %
Voltage line-to-line, V	Current, A	Phase angle, degree	Power P_{A0} (P_{B0}, P_{C0}), W	Output code	Value, W		Output code	Value, W		Output code	Value, W	
$P_{L\ nom}$ =____________ k2 = __________												

Conclusion: ____

F.5.7 Active Power of the System Tests (3-Wire)

Check point				Transducer under test reading P_1		Intrinsic error γ, %
Voltage line-to-line, V	Current, A	Phase angle, degree	Standard reading **Po**, W	Output code	Value, W	
P_{nom} =____________ k2 = __________						

Conclusion: ____

F.5.8 Reactive Power Tests, per phase **$Q_{ph} = U_{ph} I_{ph} \cdot \sin\varphi_{ph}$** (4-Wire)

Check point				Transducer under test reading Q_{A1}		Intrinsic error γ, %	Transducer under test reading Q_{B1}		Intrinsic error γ, %	Transducer under test reading Q_{C1}		Intrinsic error γ, %
Voltage line-to-line, V	Current, A	Phase angle, degree	Power Q_{A0} (Q_{B0}, Q_{C0}), var	Output code	Value, var		Output code	Value, var		Output code	Value, var	
$Q_{L\ nom}$ =____________ k2 = __________												

F.5.9 Reactive Power of the System Tests **Q** (4-Wire)

Check point				Transducer under test reading Q_1		Intrinsic error γ, %
Voltage line-to-line, V	Current, A	Phase angle, degree	Standard reading **Qo**, var	Output code	Value, var	
Q_{nom} =____________ k2 = __________						

Conclusion: ____

F.5.10 Apparent Power Test, per phase (4-Wire)

Check point				Transducer under test reading S_{A1}		Intrinsic error γ, %	Transducer under test reading S_{B1}		Intrinsic error γ, %	Transducer under test reading S_{C1}		Intrinsic error γ, %
Voltage line-to-line, V	Current, A	Phase angle, degree	Power S_{A0} (S_{B0}, S_{C0}), V·A	Output code	Value, V·A		Output code	Value, V·A		Output code	Value, V·A	
$S_{L\ nom}$ =____________ k2 = __________												

Conclusion: ____

F.5.11 Reactive Power Tests, per phase $Q_F = \sqrt{(S_{ph}^2 - P_{ph}^2)}$ (4-Wire)

Check point				Transducer under test reading Q_{FA1}		Intrinsic error γ, %	Transducer under test reading Q_{FB1}		Intrinsic error γ, %	Transducer under test reading Q_{FC1}		Intrinsic error γ, %
Voltage line-to-line, V	Current, A	Phase angle, degree	Power Q_{FA0} (Q_{FB0}, Q_{FC0}), var	Output code	Value, var		Output code	Value, var		Output code	Value, var	
$Q_{L\ nom}$ =____________ k2 = __________												

Conclusion: ____

F.5.12 Apparent Power of the System Tests (4-Wire)

Check point					Transducer under test reading S_1		Intrinsic error γ, %
Voltage line-to-line, V	Current, A	Phase angle, degree	cos φ	Standard reading **So**, V·A	Output code	Value, V·A	
S_{nom} =____________ k2 = __________							

Conclusion: ____

F.5.13 Frequency Tests

Standard reaing, Hz	Tested Transducer reading **f**		Intrinsic error γ, %
	Output code	Value, Hz	
f_{nom} =__50 Hz_______ k3 = __________			

Conclusion: ____

F.5.14 Line-to-line Voltage Tests (3-Wire)

Check point U_{AB0} (U_{BC0}, U_{CA0}), V	Transducer under test reading U_{AB1}		Intrinsic error γ, %	Transducer under test reading U_{BC1}		Intrinsic error γ, %	Transducer under test reading U_{CA1}		Intrinsic error γ, %	Transducer under test reading U_{AV}		Intrinsic error γ, %
	Output code	Value, V		Output code	Value, V		Output code	Value, V		Output code	Value, V	
$U_{L\text{-}L\ nom}$ =____________ k1 = __________												

Conclusion:____

F.5.15 Line-to-neutral Voltage Tests (4-Wire)

Check point I_{A0} (I_{B0}, I_{C0}), A	Transducer under test reading $\mathbf{I_{A1}}$		Intrinsic error γ, %	Transducer under test reading $\mathbf{I_{B1}}$		Intrinsic error γ, %	Transducer under test reading $\mathbf{I_{C1}}$		Intrinsic error γ, %	Transducer under test reading $\mathbf{I_{AV}}$		Intrinsic error γ, %
	Output code	Value, A		Output code	Value, A		Output code	Value, A		Output code	Value, A	
I_{nom} =______________ k1 = ____________												

Conclusion: ____

F.5.16 Active Power of the System Tests (3-Wire)

Check point					Transducer under test reading $\mathbf{P_1}$		Intrinsic error γ, %
Voltage line-to-line, V	Current, A	Phase angle, degree	cos φ	Standard reading **Po**, W	Output code	Value, W	
P_{nom} =______________ k2 = ____________							

Conclusion: ____

F.5.17 Reactive Power of the System Tests (3-Wire)

Check point					Transducer under test reading $\mathbf{Q_1}$		Intrinsic error γ, %
Voltage line-to-line, V	Current, A	Phase angle, degree	sin φ	Standard reading **Qo**, var	Output code	Value, var	
Q_{nom} =______________ k2 = ____________							

Conclusion: ____

F.5.18 Apparent Power of the System Tests (3-Wire)

Check point					Transducer under test reading **S_1**		Intrinsic error γ, %
Voltage line-to-line, V	Current, A	Phase angle, degree	cos φ	Standard reading **So**, V·A	Output code	Value, V·A	
S_{nom} =_____________ k2 = ___________							

Conclusion: ____

6 Common conclusion ____

Certificate of calibration (number) is granted, or the reason of unsuitability

The chief of a gauge service ______________________ ______________________

Personal signature Interpretation of the signature

Performer ______________________ ______________________

Personal signature Interpretation of the signature

Seal ____________________

Year, month, day